WARSAW UNIVERSITY OF LIFE SCIENCES

OB-RPPD CZARNA WODA

6th International Conference on Wood Composites Modification and Machining

Conference proceedings

September 06-08., 2023

Kiry, Poland

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on Wood Composites Modification and Machining

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Contents

Long-term operation of pulse-jet filters for wood dust

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Introduction

The study specifies the value of flow resistance and separation efficiency of filter material during long-term use in pulse-jet filters for wood dust. The experiments were carried out for one type of material working in two different filtration installations in one furniture factory.

Materials and Methods

The bags were obtained from the installations after working for 67, 133 and 272 days, respectively. All tests were performed on the pilot-scale test stand under identical filtration conditions.

Results

Studies have shown that long-term use of the filter material increases airflow resistance and improves filtration efficiency. The range of these changes depends on the operating conditions of the pulse-jet filters.

Conclusions

The obtained results made it possible to determine the properties of the long-term use of filter materials in various filtration conditions.

Effects of Surface Treatment of Birch Veneers by Citric Acid on the Properties of Thermoplastic-Bonded Plywood

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Introduction

Chemical treatment of the veneer surface before bonding is an effective way to increase the adhesion of the thermoplastic polymer to the wood. This study made a pioneering effort to prepare formaldehyde-free plywood from veneer treated with citric acid (CA) and bonded with virgin and recycled low-density polyethylene (LDPE) films.

Materials and Methods

The samples of birch (*Betula*) veneers were pre-treated by CA with different concentrations and dosages to improve their interfacial adhesion to LDPE film. The virgin and recycled LDPE films were used for the bonding of the wood veneers. Three-layer plywood samples were prepared under the following pressing parameters: pressure of 1.4 MPa, temperature of 160 °C, and time of 4.5 min.

Results

The CA treatment was proven to enhance the analysed properties of plywood. Plywood bonding with virgin LDPE film provided better properties than bonding with recycled LDPE film. All plywood samples manufactured in this study met the requirements for shear strength according to European standard EN 314-2.

Conclusions

The treatment of the surface of birch veneer by CA in the manufacture of plywood bonded with virgin and recycled LDPE film as an adhesive improves the compatibility of multipolar materials such as hydrophilic wood and hydrophobic thermoplastic polymers.

Acknowledgement

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Influence of pine wood sawing technology on material efficiency indicators

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Abstract

Coniferous wood processing is one of the basic methods of using natural wood resources. The aim of the work was to determine the impact of the selection of wood cutting technology, which plays an important role in shaping the material indices, especially the volumetric efficiency index. In the case of pine wood processing, group and individual technologies were assessed.. The use of frame saws guarantees the achievement of repeated sorting's with a quantitative efficiency rate of 69%. The introduction of individual technology based on band saws results in an increase in quantitative sawing efficiency to 72%. The selection of processing technology and the dimensional structure of processed roundwood have a significant impact on the average sawing rate.

Keywords: scotch pine, sawing, timber, classification, productivity

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Determination of specific cutting force for selected wood materials

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Abstract

Machinability is one of the most important technological properties in the machining process. Today's industry is more interested in knowing the machinability index than before, as machining efficiency will affect the optimal, economic utilization of a CNC machine tool. The tests consisted in drilling through holes with a polycrystalline diamond tool in materials such as: MDF, chipboard, plywood, HPL. Different cutting parameters (v_c and f_n) were used in the tests. The aim of the research was to determine the value of the unit cutting resistance. For the analysis of the recorded axial force and cutting torque signals, an innovative methodology for determining the signal values was proposed. The obtained results were used to determine the machinability index. The results obtained during the tests showed that the machinability index based on the criteria used in the work is constant for a given workpiece and does not depend on the cutting parameters.

Characteristic of particles created by preparatory operations of the particleboard production process

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Introduction

The wood-based panels production taking into account material innovations involves the need to adapt the operation of technological equipment to the properties of basic and auxiliary materials. The wide base of raw materials is associated with the occurrence of differences between individual materials, which is particularly evident in the preparatory part of the board production process during cutting and sorting operations and auxiliary operations (transport and storage).

Materials and Methods

The mass efficiency of the materials during shredding of lignocellulosic raw materials was determined by measuring the weight of the input and the weight of the particles obtained. Subsequently, the shredded materials were sorted, which was characterized by the sorting acuity number, which is the percentage of the specific fraction in the whole mixture.

Results

Assessing the quality of technological particles is a key factor in determining in-process performance, as lignocellulosic materials vary in their material indices.

Conclusions

Due to the fact that the ratios are different, it is necessary to adapt the parameters of technological operations to the specific characteristics of the raw material being processed.

Identification of the workpiece material based on the of signals from the cutting zone

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Abstract
Due to their structure, wood materials may have different properties, such as hardness, coefficient of thermal expansion, Young's modulus or thermal conductivity. This can affect tool wear or surface quality. To properly perform machining, especially in sandwich materials, a method of identifying the workpiece based on signals coming from the cutting zone may be useful. In the tests, a single-edge drill made of sintered carbide with a diamond insert for through holes was used. With different cutting parameters (v_c and f_z), holes were drilled in four materials: MDF board, plywood, chipboard, and HPL board. During drilling, the signals of axial force, cutting torque, acoustic emission and displacements were measured and recorded. On the basis of the tests carried out, it can be concluded that it is possible to identify the workpiece on the basis of signals coming from the cutting zone.

The effect of operational parameters on the size of chips in the finishing wood-based materials by milling

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Introduction

Furniture making is today heavily dependent on the use of wood-based materials. Using materials made of various wooden parts is more relevant, due to the agenda of using recycled materials and because wood composites consist of various wood shavings, flakes, wafers, chips, sawdust, strands, slivers, wood wool, fibers, and other parts which cannot be used elsewhere and thus are considered as recyclable. During the manufacturing phase, the change in shape, size, and volume of those materials is primarily a result of the mechanical processes. During the interaction between tool and material in the processes of milling, the production of the main product is always associated with the making of a secondary product, which is also in the form of a chip. From the point of chip size, there is a hidden threat, because not all size ranges of chip particles are equally hazardous. The human upper respiratory system can filter out the larger particles, but the smallest particles can penetrate deep into the lungs causing damage and scarring the lung tissue. Occupational hazards are the main sources of health issues today. Worldwide particulate matter emissions present the main environmental issue of health illnesses, and air pollution causes premature deaths. Wood dust can be potentially hazardous even because can lead to asthma or cancer. The source of increased dustiness in woodworking industries may be also associated even with the mechanical processes of woodworking. Increased dustiness in woodworking industries is dangerous. Smaller particles tend to spread in the air quite quickly which makes them hard to catch and transport by extraction system. Thus, we decided to study how much different technological conditions could potentially lead to decreasing the content of small-size particles. In this conference article, we are focusing on studying the effect of operational parameters on the creation of dust-size particles of chips in the process of milling from the point of the granulometric composition. The article compares differences between the amount of dust particles of two wood-based materials, by studying the effect of feed rates of the spiral shapes cutting tool, and the depths of cut on the creation of dust-size chip particles. The size of particles is analyzed by sieve analysis.

Materials and Methods

The raw particleboard and raw medium-density fiberboard of thickness 18 mm were milled in the experiment. Three different variables were studied to determine their effect on the amount of chip dust-size particles. In the experimental setup, we were varying the variables the feed speeds (8, 10, 12 m/min), and depth of the cuts (1, 2, 3 mm) using a spiral shank milling cutter. Other variables remain constant as much as possible. The particle mass size distribution (PMSD) was determined by sieving analysis off-site at the laboratory condition. A special set of stacked sieves with standardized sieve sizes were used for this experiment to determine the size

ranges of individual chip particles. The tool used during the milling process was a new positive diamond spiral shank milling cutter with a negative ending which is commonly used in furniture manufacturing. The results of the test were analyzed by multi-way analysis of variances.

Results

The majority of created particles of the chip are in the size range of 0.125mm for medium-density fiberboard, and 0.250mm for particleboard. There is no significant pattern in a decrease of the individual size ranges for different particle sizes, however, from the point of percentual composition, it can be stated that increasing feed speed lowers the amount of fractions in the size range of the fine type.

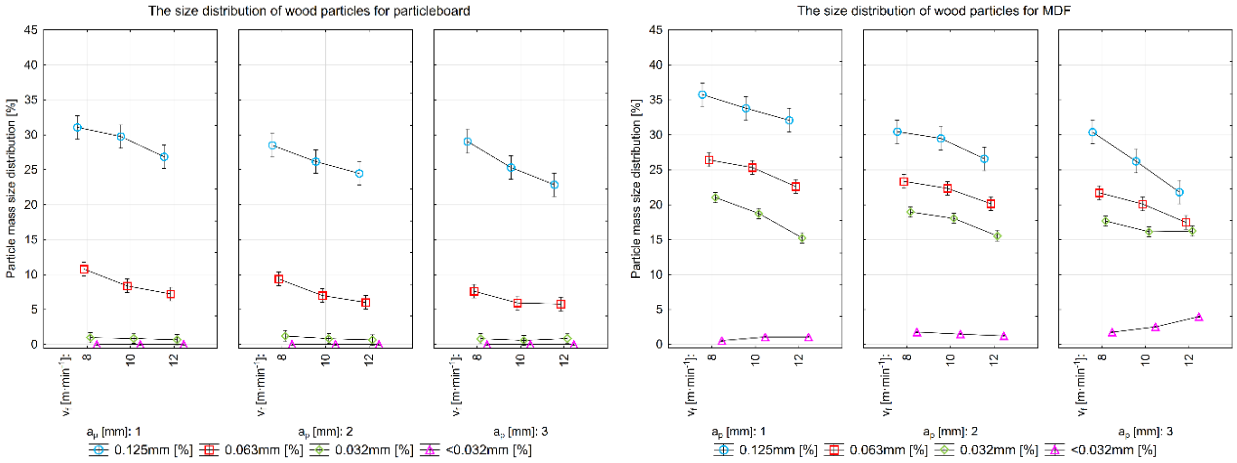

Fig. 1 The ANOVA results of wood particle size distribution for particleboard and medium-density fibreboard.

Based on observations from fig.1, there is present a significant decrease in the content of dust particles in the range of fine type with increasing the feed speed for particleboard and MDF. The relationship between increasing the depth of cut and decreasing the content of particles below the size range <0.032mm in the MDF case is unclear. However, statistical results of multi-way analysis of variances prove that the material, feed speed, depth of cut, and various combinations of those variables are significant.

Conclusions

The results show, that depending on the material, a quite different amount of dust particles would be created which is statistically proven. Medium-density fiberboards create more of the total fine fractions type compared to particleboards. The experiment also shows that it is possible to reduce the content of dust particles by increasing feed speed. It is highly recommended to choose a high feed rate as the manufacturing process is allowing. The test results can be used in the optimization process for CNC milling machines to minimize the airborne dust-size particles generated during milling and thus reduce dust exposure.

Acknowledgement:

This experimental research was prepared within the grant project: VEGA 1/0324/21 "*Analysis of the risks of changes in the material composition and technological background on the quality of the working environment in small and medium-sized wood processing companies*" as the result of work of author and the considerable assistance of the APVV agency.

The efficiency of the formatting and milling module of the technological line for door frames production

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Introduction

The efficiency of production equipment is a key performance indicator (KPI) used in manufacturing systems evaluation. It is essential for mass customization characterized by high product individualization while maintaining relatively low costs and mass-production efficiency. Designing and implementing new mass-customized technological lines should assume the possibility of achieving the highest possible efficiency.

Materials and Methods

Technological tests aimed at verifying the design assumptions regarding processing times on individual sections of the frame formatting and milling module were carried out. In the tests, sets of Porta System door frames were used, which are reference door frames, and selected structural solutions of customized door frames. The measured value characterizing the machining process was the line tact.

Results

During the test, the design's ability to achieve a capacity of more than 3 pcs./min was confirmed. However, changes in the construction and dimensions of the processed frames may affect the efficiency of the line in a certain way. Such high productivity is achieved while maintaining the required machining quality.

Conclusions

With the complete automation of all transport and handling actions and technological operations performed, it is possible to achieve the design capacity of 3 pcs/min. However, this is the maximum value. All preparation or service times will lower it. Customization of manufactured products will have a similar impact. Therefore, further research will focus on determining the best possible conditions for the use of line modules in actual production.

Design and comparison of a suitable dust separation technique during the machining process in a CNC machining center

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Abstract
The paper deals with the issue of chip extraction from the milling process in a CNC machining centre. The aim of the paper was to compare the particle size distribution of dust generated in the milling process of natural wood (beech, oak, and spruce) and MDF on a 5-axis CNC machining centre. The particle size distribution was evaluated using sieve analysis of samples from the total weight of the captured dust. The results showed that the processing of natural wood is mainly characterized by the formation of coarse dust fractions (2 mm - 1 mm sieves), while the processing of MDF was associated with the formation of fine dust fractions with a size below 100 μm. Another of the objectives was to compare the separation values on the fractional separation curves of selected mechanical separators and filters with the size distribution of dust particles and to propose a suitable separation technique that meets the criteria of "best available technique" (BAT) in the processing of natural wood and MDF, as well as to point out the creation of and the production of harmful dust fractions, which arise mainly during the processing of MDF. Our intention was to assess whether the introduction of the given technology with the given material mix will also require modifications on the side of the extraction device.

Keywords: wood processing, medium density fibreboard, CNC machining centre

Properties of fiber-gypsum composite formed on the basis of hemp (*Cannabies sativa* L.) fibers grown in Poland and natural gypsum

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Abstract
Gypsum is one of the most important building materials due to its relatively low price and widespread availability. In Poland, calcium sulfate is mainly obtained from two types of sources, namely natural deposits of the raw material (domestic resources are estimated at nearly 254 million Mg) (Szuflicki et al. 2020) and from wet lime flue gas desulfurization processes at coal-fired power plants (about 2.9 million Mg are produced each year) (Pichniarczyk 2000, Kania 2019). Regardless of the source of extraction, gypsums are characterized by the same chemical composition (Czernik et al. 2021). On the other hand, they have different: water-gypsum ratio, shape and size of grains, and mechanical properties of the produced joints. A common feature is also brittleness and a tendency to crack (Hošťálková et al. 2019). In an effort to reduce these drawbacks, various elongated materials (filler) have long been introduced into gypsum joints (matrix) with the intention of acting as reinforcement and reducing the density of the composites thus produced. Recognizing the trend of increasing cultivation of hemp seed both domestically and internationally (Czapluk and Czerniak 2020), it was decided to determine whether it is possible to produce fiber-gypsum composites and to determine the properties of the produced composites. Prior to the start of the study, the materials needed to produce the composites were measured and characterized. The fabricated fiber-gypsum composites with different fiber contents were subjected to tests to determine static bending strength, tensile strength and heat transfer coefficient. The effect of hemp fiber content on the density of the produced composites was also determined.

Keywords: composites, hemp, gypsum, strength

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Universal Design in Kitchen Furniture: A Case Study on Enhancing Accessibility and Safety for the Elderly and People with Mobility Challenges

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Abstract: *Universal Design in Kitchen Furniture: A Case Study on Enhancing Accessibility and Safety for the Elderly and People with Mobility Challenges*. The paper aims to explore the application of universal design principles in the development of kitchen furniture that promotes accessibility, safety, and independence for the elderly and individuals with mobility challenges. The study presents how innovative product design can contribute to the creation of an inclusive and barrier-free environment, emphasizing the importance of research and development works in this under-studied area. The results of the field tests that involved 200 participants with various types of disabilities, including people with motor challenges, are presented. The test results showed that the kitchen prototype developed by JATI company is comfortable and functional for the majority of test participants. The prototype has its undeniable strengths, nevertheless, several possible improvements were found during the field tests that could further improve the functionality and accessibility of the furniture for the elderly and individuals with special needs. Those are presented in the paper to inspire other furniture designers and manufacturers to create products that meet the needs and requirements of those essential society groups.

Keywords: universal design, kitchen furniture, accessibility, elderly, wheelchair users

Chip grain size from the process of machining steamed and unsteamed alder wood on a CNC machining center and assessment of separation results

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Introduction

Chips created in the process of milling wood on a CNC machining center is a polydisperse bulk material of various grain sizes from coarse, medium coarse and dust fractions. The representation of individual fractions from CNC milling processes depends on the properties of the processed raw material, the tool parameters, as well as the technical-technological parameters of the machining process. Coarse and medium-thick chips formed by milling on CNC centers have a fibrous shape, the length of which is several times greater than the width and thickness. Fine fractions with dimensions less than 125 μm are isometric chips that are approximately the same size in all three dimensions. Wood dust with a grain size in the range of 1 ÷ 500 μm is a hygroscopic, slightly abrasive, loose substance. From the aspect of the influence of dust particles with dimensions below 100 μm on the human respiratory system, dust particles are divided into respirable (inhalable) mass fraction < 100 μm, thoracic 5 ÷ 10 μm, tracheobronchial (respirable mass fraction) 2.5 ÷ 5 μm, highly respirable mass fraction fraction < 2.5 μm.

The aim of the work is to compare the grain size of steamed alder wood chips with non-steamed alder wood chips created in the milling process on the SCM Tech Z5 CNC machining center under the same machining conditions and to assess the suitability of the Finet PES 4 filter fabric for capturing chips extracted from transport air in the fabric filter FR - SP 50/4.

Materials and Methods

Material: alder wood was processed in the experiment in the form of blanks:
- steamed alder wood with saturated water steam at a temperature of t = 135 °C for a period of τ = 9 hours. with dimensions: 50 x 80 x 500 mm,
- unsteamed alder wood with dimensions: 50 x 80 x 500 mm,
- wood moisture of unsteamed and steamed blanks w = 10 ± 2%.

CNC machining center: the experiment was carried out on a 5-axis CNC machining center SCM Tech Z5 (Figure 1). Milling of the blanks was carried out with a single-blade end mill with the type designation KARNED 4451 from the manufacturer Karned Tools s.r.o., Prague, Czech Republic. A reversible knife HW 49.5/9/1.5 made of T10MG sintered carbide was installed in the end mill. Technological conditions of milling:

- cutter speed n = 20,000 min^{-1},
- feed speed v_f = 2 $m.min^{-1}$, v_f = 4 $m.min^{-1}$ and v_f = 6 $m.min^{-1}$,
- when removing e = 1 mm, e = 3 mm, e = 5 mm.

Fig.1 CNC machining center SCM Tech Z5

Results

From the analysis of the size of the chips formed in the milling process on the SCM Tech Z5 CNC machining center presented in Table 1, Fig. 3. and 4. it follows that the majority share in the formed loose wood matter, both in unsteamed and steamed alder wood, are chips of the coarse fraction. The average representation of the coarse fraction of chips from the milling of non-steamed alder wood is 66%, and for steamed wood this fraction is about 3.1% lower. The proportions of this fraction of chips in both types of alder wood decrease with the growth of removal and increase of the sliding speed. The average representation of the medium-coarse fraction of chips with dimensions of 0.125 - 1.0 mm in non-steamed alder is 29.5% and in steamed alder wood 32.7%. Dust fractions with dimensions below 125 μm are represented to the smallest extent in the created loose wood mass. The average representation of the dust fraction from unsteamed alder wood is 4.5% and from steamed alder wood 4.4%. Chips of both unsteamed and steamed alder wood with dimensions below 32 μm were not measured, so it can be concluded that no respirable dust particles with dimensions below < 10 μm are formed. Based on a comparison of the separation limit of the a_{MO} filter fabric Finet PES 4 and the size of the smallest chips of the extracted amine sawdust, it can be concluded that on the Finet PES 4 filter fabric in the fabric filter FR-SP 50/4, all extracted chips are captured and separated from the transport air.

Conclusions

Changes in the physical and mechanical properties of steamed alder wood as a result of steaming with saturated steam at a temperature of t = 135 °C are manifested in a decrease in the coarse fraction above 2 mm and an increase in the fraction of chips from 0.125 to 2000 μm. Fabric filters and Finet PES 4 filter fabric are suitable for separating chips of both unsteamed and steamed alder wood from the transport air, the separation limit of which is smaller than the size of the smallest chips formed in the milling process: $a_{MO} = 7$ μm < $a_{min} = 32$ μm.

Acknowledgements

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Colourfulness of European beech wood with a round false heartwood in the color space CIE L*a*b*

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Introduction

The color of the wood is a basic physical-optical property that belongs to the group of macroscopic signs on the basis of which the wood of individual trees differs from one another in appearance.

Reflected electromagnetic radiation entering a person's eye creates a psychophysiological sensation in the person's mind, manifested by the perception of the color of the observed object.

The wood of the forest beech belongs to the scattered-porous, coreless woods with the possibility of forming a false heartwood. In some older trees, there is red-brown wood in the middle of the trunk, the so-called wrong core. A false heartwood is a growth defect that arises in the zone of mature wood by reactions of atmospheric oxygen with wood. The primary cause of a false heartwood is the penetration of air into the tree trunk through wounded areas of the trunk or branches of the tree and the subsequent oxidation of soluble carbohydrates and starch contained in living or partially dead parenchymal cells in mature wood.

The aim of the work is to determine the color of the healthy wood of the round false heartwood of *Fagus sylvatica* L in the color space CIE L*a*b and to analyze the natural variability of the color of the dry wood of the false heartwood.

Materials and Methods

The measurement of the color of the wood of the false heartwood was performed on beech wood from Štiavnické vrchy (Slovakia). 30 sections with a healthy round false heartwood were selected from each location. 5 pieces of blanks with dimensions of 24 x 38 x 800 mm were randomly selected from the central lumber of each cutout.

In order to preserve the original color of the wood, the blanks were dried in an air-conditioned room at a temperature of t = 20 °C and a relative humidity of φ = 60% to a moisture content of w = 10 ± 0.5%. The bearing surfaces of dry blanks and false heartwood were machined on a horizontal plane milling machine FS 200.

The color of the wood of the beech blanks in the color space CIE L*a*b* was measured with a Color reader CR-10 colorimeter (Konica Minolta, Japan). A D65 light source was used and the diameter of the optical sensing aperture was 8 mm.

Results

The color shades of samples of dry beech wood with false core are shown in Fig.1. According to the visual assessment, the color of the wood of the false heartwood is from brown-yellow to red-brown. The results of statistical processing of the measured color values of beech wood samples on the individual coordinates of the color space CIE L*a*b* are shown in Table 1.

Fig. 1 The colour of the false heartwood beech (on the samples on the right) and mature wood (in the samples on the left).

Table 1. Coordinate values of the color space CIE L*a*b* describing the color of beech wood.

Beech wood, false heartwood	Color coordinates		
	L*	a*	b*
Number of measurements [-]	150	150	150
Measured value [-]	65.9 ± 4.8	12.7 ± 2.1	20.3 ± 1.9
Standard deviation s_x [-]	4.8	2.1	1.9
Coefficient of variation v_x [%]	7.3	16.2	9.3

Dispersion of the wood color of the false core, manifested by the variety of darkness and yellow-brown-red color shades of the wood, numerically characterizes the dispersion of the measured data expressed by standard deviations: lightness s_x = 4.8, red color s_x = 2.1 and yellow color s_x = 1.7. Red color has the greatest influence on the color dispersion of false heartwood, whose value of variation coefficient v_x = 16.2% is 2.2 times greater than the value of variation coefficient of lightness L* and 1.7 times greater than the value of variation coefficient of yellow color a*. The dispersion of the color of the wood of the false heartwood in the color space CIE L*a*b* expressed in the form of the total color difference ΔE* = 5.5. Within the categorization of color difference, the stated value of the total color difference ranks the variance of the color of the false core wood in the category of visible color changes.

Conclusions

The dispersion of the color of the wood of the false heartwood in the color space CIE L*a*b* expressed in the form of the total color difference ΔE* = 5.5. Within the categorization of color difference, the indicated value of the total color, the difference between brown-yellow and red-brown color belongs to the category of visible color changes. Red color has the greatest influence on the color dispersion of false core wood, whose value of variation coefficient v_x = 16.2% is 2.2 times greater than the value of variation coefficient of lightness L* and 1.7 times greater than the value of variation coefficient of yellow color a*.

Ackonwledgement:

This experimental research was prepared within the grant project: APVV-21-0051 *Research of false heartwood and sapwood of Fagus sylvatica* L. *wood in order to eliminate color differences by the process of thermal treatment with saturated water steam* as the result of work of author and the considerable assistance of the APVV agency.

The colour difference of transparent surface finish on hydrothermally treated beech wood in the interior

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Introduction

Colour is one of the aesthetic properties that can be identified subjectively with the naked eye, or measured objectively using the spectrophotometer. The surface of wood treated hydrothermally with saturated water vapour needs to be finished with transparent coating materials to preserve the colour and an attractive appearance. Transparent finishing is designed to enhance the stability of the surface of native wood and hydrothermally treated wood and to maintain the natural aspects of wood, such as colour, grain, and texture for a long time. A visible colour change in wood is the first sign of its chemical modification when exposed to diffuse indoor light conditions. The changes in colour of wood surface after applying a transparent coating material are the result of an interaction between the colour of coating film and the colour of wood surface. At the same time, the colour of finished wood surface changes due to sunlight in interior and due to ageing in dark as well. The objective of this paper is to evaluate the effects of natural sunlight or dark on the change of colour of transparent surface finishes coated on hydrothermally treated beech wood.

Materials and Methods

The measurement of the colour of wood with surface finish was performed on mature beech wood from Štiavnické vrchy (Slovakia). The samples of native and hydrothermally treated (HTT) wood were prepared from the boards, air-conditioned for six-month. The boards were conditioned at the temperature of 20 °C and a relative humidity of 60% to a moisture content of 10 ± 0.5%. They were sanded, transversely first and then in the longitudinal direction (last sandpaper grit P 180). The samples had 3 to 8 growth rings per cm, they were free from defects, and the growth ring orientation to the tested surface was 5° to 45°.

Three different transparent surface finishes for interiors were applied onto the native and hydrothermally treated wood samples according to the producer's recommendations: one-component water-based acrylic-polyurethane dispersion surface finish, Aqua TL-412-Treppenlack/50 (Acryl-PU), two-component surface finish with polyacrylic and aldehyde resin, PUR SL-212-Schichtlack/30 (PAcryl-Ald), and single-component wood sealer with alkyd resin, HWS-112-Hartwachs-Siegel/clear (Alk).

After coating, the samples were stored at 23 °C and 50% relative humidity (RH) in a dark room for 14 days to ensure film formation, sufficient hardening, and solvent evaporation.

The colour parameters of the tested samples (CIE L*a*b*, chroma C*, hue angle Δh°) were measured using a Color Reader CR-10 (Konica Minolta, Osaka, Japan). The parameters were measured immediately after coating and later after ageing in dark and in natural sunlight. The device was set to an observation angle of 10°, with d/8 geometry, and a D65 light source. The colour difference ΔE* of the sample surfaces were counted after 60 days.

Results

The colour difference ΔE* of native wood and hydrothermally treated (HTT) wood with three different surface finishes after ageing in dark and in natural sunlight are presented in Fig. 1.

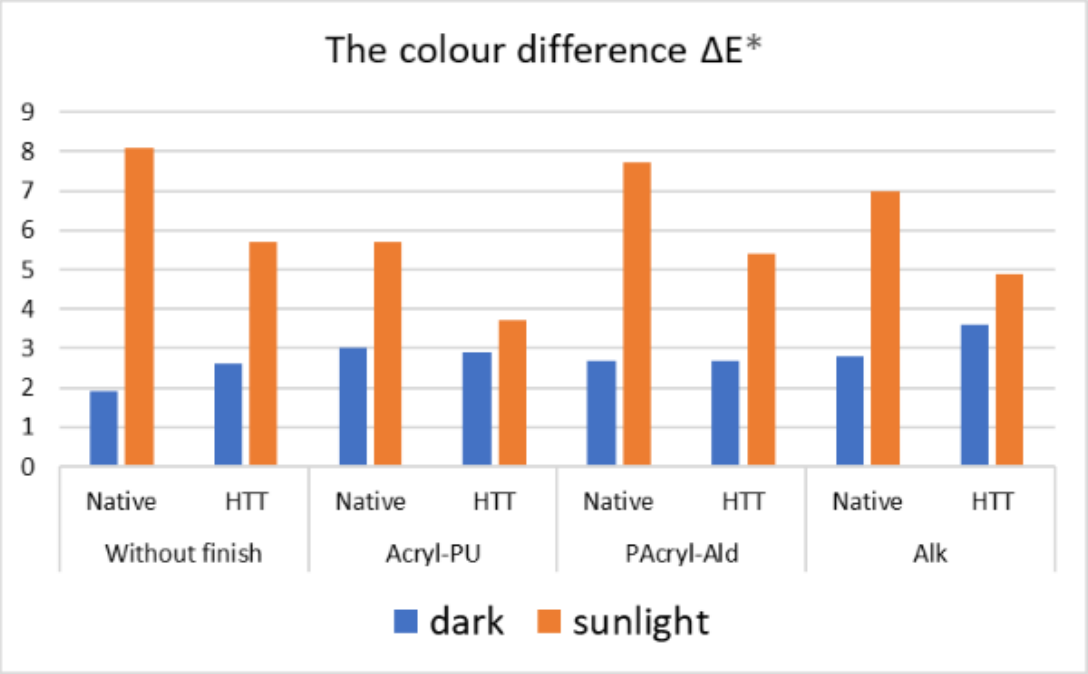


Fig. 1 The colour difference ΔE* of mature beech wood with three various surface finishes after 60-day ageing in dark and in natural sunlight.

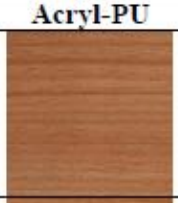
The colour of native mature wood with three different surface finishes are shown in Table 1.

Table 1. The colour of native beech wood with transparent surface finishes after ageing in dark and in natural sunlight in interior.

Conditions		Without finish	Acryl-PU	PAcryl-Ald	Alk
Native	before exposure				
	dark				
	sunlight				

The colour of hydrothermally treated wood with three different surface finishes are shown in Table 2.

Table 2. The colour of hydrothermally treated beech wood with transparent surface finishes after ageing in dark and in natural sunlight in interior.

Conditions		Without finish	Acryl-PU	PAcryl-Ald	Alk
HTT	before exposure				
	dark				
	sunlight				

The colour difference ΔE* showed that the colour of wood and the surface finishes changed after ageing under sunlight conditions and in dark, too (Fig. 1). The colour difference ΔE* was bigger in sunlight conditions than in dark. The colour difference was bigger on native wood than on hydrothermally treated wood.

Conclusions

Transparent surface finish is designed to enhance the stability of wood surface and keep the natural appearance of wood. The study has shown that surface finished wood, both native and hydrothermally treated, was susceptible to discolouration, although it was coated with transparent surface finishes (acrylic-polyurethane, polyacrylic and aldehyde resin, alkyd resin).

The surface finished hydrothermally treated wood showed smaller colour difference than surface finished native wood, when exposed to the sunlight. In dark, the colour difference of the surface finished hydrothermally treated wood was comparable to the surface finished native wood; in some cases, the colour difference was larger on the hydrothermally treated wood.

Ackonwledgement:

This experimental research was prepared within the grant project: APVV-21-0051 *Research of false heartwood and sapwood of Fagus sylvatica* L. *wood in order to eliminate color differences by the process of thermal treatment with saturated water steam* as the result of work of author and the considerable assistance of the APVV agency.

Pre-Treatment of Birch Wood by Saturated Steam

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Introduction

The treatment with water-steam represents a hydrothermal method of modification. The steam modification of wood alters its chemical and physical properties. The effect and mechanisms of the water-steam degradation process regarding changes in the chemical structure have not been fully understood in detail. The aim of this study was to study the surface properties, chemical changes, and microscopic alterations of selected wood species.

Materials and Methods

The samples of birch (*Betula*) were pre-treated with saturated water steam at these conditions: temperature of 125 °C, treatment time of 8 hours, and pressure of 0.18 MPa. The physical and chemical changes were stated by contact angle, ATR-FTIR, XPS, and SEM measurements for all investigated samples of steam-treated wood.

Results

After the modification of birch wood with saturated water steam, the water contact angle increased. It can be stated that the amount of oxygenated functional groups in birch wood determined by the FTIR after steam treatment decreased. The decrease in oxygen (O1s) measured by XPS was also confirmed by the results of FTIR measurements.

Conclusions

The hydrophobicity of birch wood after water-steam modification has been found to increase. XPS and FTIR measurements confirmed a decrease in oxygenic functional groups content as well as an increase in carbon content on the birch wood surface.

Acknowledgement

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The Impact of Abrasive Grit Size on Roughness of Sanded Beech Wood Surface

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Abstract

The study assessed the changing of Ra, Rp, Rv and Rz roughness parameters of the sanded beech surface (Fagus sylvatica L.) as a function of different grit sizes and different measurement direction. The milled samples were ground with a belt sander BS-75 E-set from Festool with belt grit P60, P100 and P150. The sanding belts were Rubin 2 from Festool. Roughness was evaluated using a Keyence VHX-7000 digital microscope. The evaluation length of the roughness measurement was 12.5 mm (λc = 2.5 mm and λs = 8 mm). The R-parameters were measured in accordance with the latest standards ISO 21920 (2022) in the direction parallel to the grain, and in the direction perpendicular to the grain (profile). The paper proves the theoretical assumptions about the reduction of R-parameter values. The measurements showed that the sanded surface was less rough in the direction perpendicular to the grain at P150 sanding belt grit and in the grain direction at P100 grit.

Key words: surface roughness, belt sander, beech wood, Keyence VHX, digital microscopy

Tilt Angle of Wood Dust

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Introduction

Wood industry belongs to the risk branches of the industry, where almost all harmful factors of the working environment can be characterized and it is unacceptable to solve this situation only on a theoretical level and employers should necessarily proceed with the practical implementation of the elimination or reduction of the occurring risk factors in their operations. On the basis of many tools for solving this question, we have selected the manual "Basics of risk assessment - Good for you, Good for your company" where a checklist of hazards is presented, also for wood processing.
The aim of the submitted contribution is by using the tilt angle of wood dust, to characterize the selected hazard from the checklist for wood processing - item air quality: "Do you clean and wipe dust from ceilings, partitions on walls and cable lines?"

Materials and Methods

Sawdust (spruce, beech, w = 10 ÷ 12 %) from the process of longitudinal sawing on a table circular saw, using 2 types of saw blades, SB2 – larger chip thickness. Sanding dust (spruce, pine, oak, beech, w = 6 ÷ 8 %) from the process of longitudinal and transversal sanding on hand belt sander, grit size of sanding belts 80.
Tilt angle measuring device with different surfaces.

Results

The smaller the particles are the higher adherence to the surface and greater the tilt angles are. For sanding dust the interval of tilt angle is from 33° to 57° and for sawdust this value is from 27° to 34°.

Conclusions

Based on the results, it can be concluded that the dust on various structures, partitions, on the stored material that is being processed is retained even on too inclined surfaces and in the case of insufficient cleaning is a source of secondary dustiness.

Modification of UF Adhesives with Natural Keratin Scavengers of Formaldehyde from Wood-Based Panels

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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 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 keratin with a high content of natural organic sulphur (up to 4%) and its modifications.

Materials and Methods

The samples were characterised by X-ray photoelectron spectroscopy (XPS), FTIR-ATR spectroscopy, and elemental analysis of elements C, H, N, S on the varioMACROcube device from ELEMENTAR. Formaldehyde emission from 5-layer beech (*Fagus*) 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 differences between the XPS and FTIR-ATR spectra are visible in the amounts of carbon, oxygen, sulphur, and for sulphur also in the ratio of its reduced and oxidized forms. The most significant decrease in formaldehyde emissions, up to 30.7%, was achieved with the modification of the keratin sample, modified by the application of a sulphur additive and 5% $Ca(OH)_2$. Tested plywood fulfils the requirements of the standard for gluing class 1.

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 keratin samples in comparison with the reference sample.

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Pre-Treatment of Wood by Cold Plasma

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Introduction

For wide industrial utilization, different woods have to possess a large set of various surface characteristics. The nanoscale dimension changes in the plasma-treated wood have been carried out while maintaining the desirable material properties. The enhancement of wood hydrophilicity is a necessary condition to promote better adhesion with water-based adhesives and coatings.

Materials and Methods

Three wood species: beech (*Fagus*), birch (*Betula*), and maple (*Acer*) with dimensions 50×15×5 mm (Technical University in Zvolen, Slovakia). The coplanar discharge plasma was used for the treatment of the selected wood species. The contact angle meter, FTIR, and XPS were used for the characterization of plasma-treated wood.

Results

The contact angle of water on the investigated wood surfaces diminished with the time of modification by cold plasma and showed a steep decrease from 72° (beech wood) to 50° after modification by plasma for 120 s. ATR-FTIR spectra confirm the increase in hardwood polarity and hydrophilicity after cold plasma treatment in air due to growth in –OH group amount.

Conclusions

The water contact angle of selected wood treated by cold plasma in the air strongly decreased with plasma activation time. The concentration of oxygen after plasma treatment of wood increased, and the amount of carbon during plasma treatment of wood conversely decreased. The content of –C–O, COOH, and C=O groups after treatment by discharge plasma significantly increased.

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Assessment of Hot-Melt Adhesives Metallocene Polyolefin-Based

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Introduction

Metallocene polyolefins are highly hydrophobic polymers with low surface energy, especially in their polar component. For the preparation of hot-melt adhesives (HMA), it is desirable to increase the polarity of the metallocene polyolefin (MePO) by chemical modification aimed at incorporating more polar polymers into prepared polymer blends. The grafted MePO was then used as a modifier for a selected HMA, and the surface properties and adhesion of this system towards selected materials were studied.

Materials and Methods

The random metallocene ethylene-co-polypropylene copolymer Licocene PP 2602 (Clariant) was modified by ozonation and grafting with acrylic acid (AA) and used for HMA preparation. The contact angles were measured using a set of testing liquids. The adhesion value was determined as the tensile strength of adhesive joint HMA-paper to pull out one paper sheet.

Results

The addition of 0.544 wt.% of polar component (Licocene PP 2602 grafted by AA) to HMA increased the polar component of surface energy from 1.8 up to 3.3 $mJ.m^{-2}$, and the strength of adhesive joint HMA-paper also increased from 117.9 to 142.3 N/90 mm.

Conclusions

The hydrophilicity of the metallocene ethylene-propylene copolymer after modification by acrylic acid increased. The addition of a small amount of modified metallocene ethylene-propylene copolymer to basic hot-melt adhesive markedly increases the adhesion to paper.

Acknowledgement

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Impact of Seat and Back Angle Settings on Seating Furniture Quality: An Experimental Study

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Abstract
The measure of the quality of seating furniture is its functionality, also referred to as seating comfort. Sitting comfort is described in the literature by the discomfort coefficient D, which is calculated from the actual pressure distribution measured on the seat body support system. The work aims to experimentally verify the influence of selected anthropometric features on sitting comfort. The research was carried out on a group of 12 people. The influence of seat and backrest inclination geometry variants on the distribution of usable pressures on a model of lounge furniture was investigated. The piezoelectric sensor mat was used in the study. The test results are the values of the discomfort coefficient D for nine combinations of the backrest and seat inclination related to the anthropometric characteristics of the tested group of people. The results indicate that anthropometric characteristics, such as body mass index (BMI) and user's gender, significantly impact objective seating comfort. These studies will help optimize the seating and lounge furniture dimensions at the design stage.

Keywords: anthropometry; furniture design; design quality; pressure map

Selected properties of the new wooden material

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Introduction

The aim of this study was to determine the varnishability of an innovative wood product obtained from the rods of fast-growing shrub willow (*Salix viminalis* L.) species. The surface adhesion properties of the obtained products and the aesthetic and decorative features of the finishing were evaluated.

Materials and Methods

For the surface finishing tests, the components from elements of bonded rods of shrub willow wood made in the Research & Development Centre for Wood-Based Panels Sp. z o. o. in Czarna Woda**.** The surfaces were finished using acrylic (AC) and polyurethane (PUR) lacquer products.
The obtained coatings were subjected to visual assessment and tests of colour and adhesion strength to the substrate. Testing of appearance was carried out acc. to the PN-88/F-06100/01 standard.
Colour determinations were carried out with a DT-145 colourimeter using the CIELab measuring system.
Measurements of the adhesion strength of the lacquer coatings to the substrate were carried out acc. to the EN ISO 4624 standard. The images of delamination at destructive loadings were assessed visually.

Conclusions

The obtained finishings were characterised by high aesthetic and decorative features.
The value of ΔE, which determines the colour changes after the lacquer products have been applied to the substrate, indicates changes recognisable by an inexperienced observer.
Coatings of the tested lacquer products showed good adhesion strength to the substrate, however, with varying delamination mechanisms.
The resulting innovative willow product is an interesting solution that has been applied for at the Polish Patent Office (Application No. 445547).

Probing measurements of the Meyer hardness index of longitudinal and cross sections of various types of wood

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Introduction

The Meyer index is a power exponent appearing in Meyer's hardness power law, which describes the dependence of the indenting force on the diameter of the indentation caused by the ball (or alternatively a cylinder). A perfectly plastic material should have a Meyer hardness index of 2 and a perfectly elastic material of 3. Previous research by the author and co-workers indicated that the Meyer index of copper is 2.0, aluminum 2.25, and beech wood 2.5. This gave rise to the hypothesis that the hardness index of each wood is about 2.5. It was decided to verify this hypothesis for different types of wood, different anatomical cross-sectional directions and different humidity. Research on such diversity must therefore be of a probing nature.

Materials and Methods

In addition to the reference beech wood, it was decided to study the representatives of the four basic structural types of wood: pine (coniferous wood), birch (diffuse-porous), oak (ring-porous), merbau (exotic hardwood). The research include longitudinal (radial) and cross-sections of wood in two states of absolute humidity (about 8% and 12%). Thus, each type of wood was tested in four potentially different ways. If these methods are included for the four types of wood tested, along with the reference beech, this gives 20 independent measurements of the Meyer hardness index.
The measurement of one Meyer index is based on 20 indentations in the diameter range from 3 mm to 12 mm, made with a ball with a diameter of 15 mm subjected to the pressure of the maximum force with a value appropriately selected for the size of the indentation and the type of wood. The main wood samples were size of 20 x 20 x 300 mm, but each was cut into 10 smaller samples of 20 x 20 x 28 mm..

Results

The research will last until May. They will then be published in the conference materials and presented at the conference.

Conclusions

Conclusions will be determined by the obtained probing results of measurements. If the research hypothesis about the Meyer hardness index of wood equal to 2.5 is initially confirmed, then it will be possible to confirm this hypothesis in further research at a higher level of significance, on a larger number of samples. If the hypothesis is not initially confirmed, further research will also be needed, aimed at new research hypotheses or at rejecting the original hypothesis at the appropriate level of significance.

Adhesion properties of UV varnish systems to selected plasma-activated plastic surfaces under industrial conditions

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Introduction

In recent years, various modifications are being made to surface finishing technologies, including analog and digital printing. Apart from optimizing the application parameters of individual varnish products, low-energy sources of electromagnetic radiation, such as LED, are being introduced. In addition, for materials with limited susceptibility to varnishing, methods of activating the surface before finishing are being used. The challenge under production conditions is to maintain a short time from activation to application of the varnish product. The aim of this study was to determine the effect of plasma activation of edgebands on the adhesion of UV-hardened coating systems.

Materials and Methods

The material was prepared in the technological conditions of the BORNE FURNITURE Comp. in Gorzow Wlkp. (Poland). Edges (ABS and PP) were used for testing. Surfaces were activated by plasma, and then UV varnish systems were applied and hardened.
Surface topography tests were carried out and roughness parameters were determined. The contact angle was determined using a microscopic method.
Adhesion strength tests of the tested systems were performed acc. to the PN-EN ISO 4624 standard, using an automatic hydraulic PostiTest apparatus. Images of delamination under destructive loadings were evaluated by visual method.

Conclusions

Based on the analysis of the topography of ABS and PP edges tapes, the effect of plasma surface activation on the surface structure was observed.
Different adhesion of the tested UV coating systems to the edges' surfaces was observed. This is due not only to plasma activation, but significantly to the crosslinking parameters of the tested UV coating systems.
Plasma activation of edges surfaces under industrial conditions is an interesting solution, but requires further research.

Investigation upon the Influence of Curing Parameters of UV Hg-LED Varnish Systems on the Mechanical Resistance of Coatings

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Introduction

Global efforts to eliminate mercury stimulate the development of LED lamps for curing UV coatings. The change to curing with LED lamps in the furniture industry, despite many advantages, is associated with technological problems. The aim of the work was to determine the influence of individual technological and process parameters of the varnishing line on mechanical properties such as abrasion resistance of the varnish coating on the composite board.

Materials and Methods

The composite lightweight boards were prepared using HDF sheets of varying density as facing. The samples were varnished on an industrial UV varnishing line with mercury lamps and LED modules, at a speed of 50 m/min. The experiment included 198 variants of white surface finish, taking into account various grinding methods, the number of layers of coatings, the amount of basecoats and topcoats applied, and the power of Hg and LED lamps. The Taber Abraser 5130 model 352 was used for the investigations abrasion resistance. The mass loss was measured after 100 and 200 revolutions for each three samples.

Results

Based on the statistical analysis, it was shown that the density of the facing board and the amount of basecoat had the greatest impact on the weight loss during abrasion. With increasing board density, the abrasion resistance of the coatings increases. Increasing the amount of basecoat correlates negatively with the resistance of the coatings. Of the statistically significant interactions, the interplay between the topcoat amount and the density of the HDF board emerged as the most crucial. With a decrease in the amount of topcoat on the surface of the lower density board, the resistance decreased, in contrast to the higher density board, whose resistance increased.

Conclusions

The findings underscore the potential of optimizing UV-LED varnishing processes in the furniture industry through controlled application of varnish products and board density adjustments.

The prospect of using retro timber in the furniture industry

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Introduction

To avoid over-exploitation of natural resources such as timber the idea of upcycling or reusing materials to prolong their life is quite often taken into consideration. Retro timber as a material has great potential to be reused in the furniture industry.
Therefore, it seems advisable to conduct research aimed at understanding the mechanical properties of retro timber and presenting the possibilities of its use.

Materials and Methods

Retro timber, a material that was used for more than 50 years, obtained from wooden houses in Russia was identified and samples were taken. The mechanical tests of the samples were carried out, and after obtaining the results, the design methods were implemented.
The method of designing furniture and interior design elements from retro timber was also presented.

Results

As a result, the data obtained from the mechanical tests were compared with the wood raw material used in the furniture industry. Possibilities of reusing wood in furniture constructions and interior design elements were indicated. Simple skeletal furniture has also been designed as an example of reusing retro timber.

Conclusions

The retro timber from wooden houses that have been well preserved is a potential raw material that can be used in the furniture industry. This is confirmed by the tests of the mechanical properties of the obtained wood raw material.

Lightweight sandwich panel with a profiled core layer made of WPC thin board

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Introduction

Sandwich panel are an interesting alternative to traditional boards used in the furniture industry. Their main advantage is weight reduction without significant deterioration of strength properties, stiffness, stability and other structural functions. Various variants of spatial arrangements can be used as filling. As part of this research, thin WPC composites were used for this purpose, which were shaped as a result of thermoforming. Their formation can be carried out in accordance with the individual purpose of the element. The selection of the shape may be preceded by the FEM numerical analysis.

Materials and Methods

Two variants of flat WPC composite panels based on HDPE (Hostalen GD 7255, Basell Orlen Polyolefins Sp. z o.o., Płock, Poland) with a nominal thickness of 2.5 mm were used for the tests. Coniferous sawdust with particles passing through a 0.49 mm sieve (above 35 mesh) was used as a filler. The share of the filler was: variant I - 40% and variant II - 60%. The boards were produced in accordance with the methodology contained in the publication of Borysiuk et al. 2021. The thermoforming process was carried out in a wooden mold in a press, after heating the boards in an air stream at a temperature of 200°C for 5 minutes. Two types of profile elements were produced (Fig. 1 and Fig. 2).

Fig. 1. Profile element – profil F

Fig. 2. Profile element – profil S

On the basis of the obtained profile elements, three-layer sandwich panel with external layers of HDF boards with a nominal thickness of 2.5 mm were produced. The boards were bond in a press at a temperature of 200°C for 5 minutes, and then cooled under pressure to a temperature of approx. 20°C. 3 variants of lightweight boards were produced:

- I_F: variant I (40% small sawdust + 60% HDPE) - F profile
- I_S: variant I (40% small sawdust + 60% HDPE) - S profile
- II_S: variant II (60% small sawdust + 40% HDPE) - S profile

Results

The produced sandwich panel are shown in Fig. 3. The results of the tests of the manufactured boards are presented in Table 1. With regard to the MOR and MOE values, in the case of both profiles (I_S and I_F), the obtained board strength values are comparable to the parameters of furniture particleboard, while the material density is reduced by over 20% (Niemz 1993, EN 312). In the case of compressive strength, more favorable parameters were characterized by cellular boards with filling - S profile (strength values higher by more than 37%).

Fig. 3. Lightweight sandwich panels with F-profile (top) and S-profile (bottom) filling.

Table 1. Results of the conducted tests

Variant	Density	S.Dev.	MOR	S.Dev.	MOE	S.Dev.	CS	S.Dev.
	[kg/m^3]		[N/mm^2]		[N/mm^2]		[N/mm^2]	
I_S	459 $^{a\,A}$	17	11.5 $^{a\,A}$	1.6	1876 $^{a\,A}$	283	0.62 $^{a\,A}$	0.05
II_S	435 ^{b}	12	3.4 ^{b}	0.5	894 ^{b}	101	0.47 ^{b}	0.08
I_F	484 ^{B}	22	13.2 ^{B}	1.4	2017 ^{A}	299	0.39 ^{B}	0.06

a,b A,B – homogeneous groups by Tukey test (α = 0.05); S.Dev. – standard deviation; CS - compressive strength

It can be seen that the possibility of permanent bonding between the middle layer of composite panels and HDF cladding panels depends significantly on the thermoplastic content. Reducing the thermoplastic content from 60% to 40% (I_S and II_S) resulted in a decrease in the strength parameters, respectively: MOR by about 70% and MOE by about 50%. This effect is less pronounced in relation to compressive strength, where a decrease in the strength value of about 25% was noted. The decrease in the strength parameters of the produced cellular boards results both from the lower content of the potential binder - thermoplastic, as well as from the differences in the strength parameters used for thermoforming the composite panels.

Conclusions

It is possible to produce three-layer lightweight sandwich panels based on a middle layer made of thermoformed composite boards. It has been shown that the efficiency of joining thermoplastic fittings with cladding panels of lightweight boards depends on the content of thermoplastic - an increase in the content improves the quality of connections. In turn, the strength parameters of lightweight boards are significantly influenced by the shape of the middle layer and the contact surface between the middle layer and the outer facings. In the tested variants of the panels, more favorable bending parameters were achieved by the sandwich panels with the filling - F profile, and in the compression test, the sandwich panels with the filling - S profile obtained higher parameters.

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Modelling of the similar depth profiles of two different kinds of ions implanted to WC-Co tools used in wood-based material machining

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Introduction

Ion implantation is a relatively simple and cheap method of the modification of near-surface regions of different materials, the machine elements or tools, including the tools used for wood-based material machining.

The typical value of the range of the implanted ions usually spans from tens to hundreds of nanometers, but it is sufficient to increase the tool durability by a factor of 2-3.

Therefore, it was decided to check the possibility of generating similar or identical depth profiles for two popular gases, used in laboratories and industry, i.e. chemically active nitrogen and inert argon. The atomic mass of these elements is: 14.0067 u for nitrogen, and 39.948 u for argon, so the difference is nearly 3-fold, which is evidently reflected in the positions of the depth profiles and their half-width.

Materials and Methods

W-C-Co material including (at.%): 47.4% W, 47.4% C and 5.2% Co, i.e. in wt.%: 90.86% W, 5.94% C and 3.2% Co, with the density of 15.2 g/cm3 was adopted as the substrate material to the modelling. The value of density was declared by the supplier of the e.g. KCR08 type knives (Ceratizit, Austria).

Nitrogen and argon were used as implanted elements. In the case of direct implantation, i.e. without mass separation, nitrogen is delivered as two kinds of ions, i.e. N_2^++N^+, in ~1:1 ratio, so there are two elementary charges per three atoms. In the case of the N_2^+ molecule implanted e.g. with the acceleration voltage of 25 kV, each atom carries the energy of 12.5 keV, according to the energy conservation law. The fluence of the lower energy ions (12.5 keV) is 2-fold higher than the fluence of the ions with an energy of 25 keV (Barlak et al. 2019a). For simplicity, it is assumed that the argon beam contains only one type of ion, i.e. Ar^+. The depth profile for nitrogen will be obviously the sum of two profiles for both types of nitrogen implanted ions. Thus, for the same situation assumed for argon, it is necessary to apply the sum of the two profiles, obtained for two different values of the acceleration voltage, i.e. for some value of the acceleration voltage and a half of this value.

The Stopping and Range of Ions in Matter (SRIM-2013.00), freeware type code, which is a collection of software packages which calculate many features of the transport of ions in matter, using the Monte Carlo method, was used for modelling.

Results

Figure 1 presents the results of the second stage of modelling the similar depth profiles of nitrogen and argon implanted to W-C-Co material. The upper and middle parts of the figure show the component (thin lines) and total (thick lines) profiles, with the applied parameters of the modelling. Additionally, the profile lines for argon are dashed for greater clarity, especially in the lower part. It is seen, that the total profiles for both implanted elements are very similar.

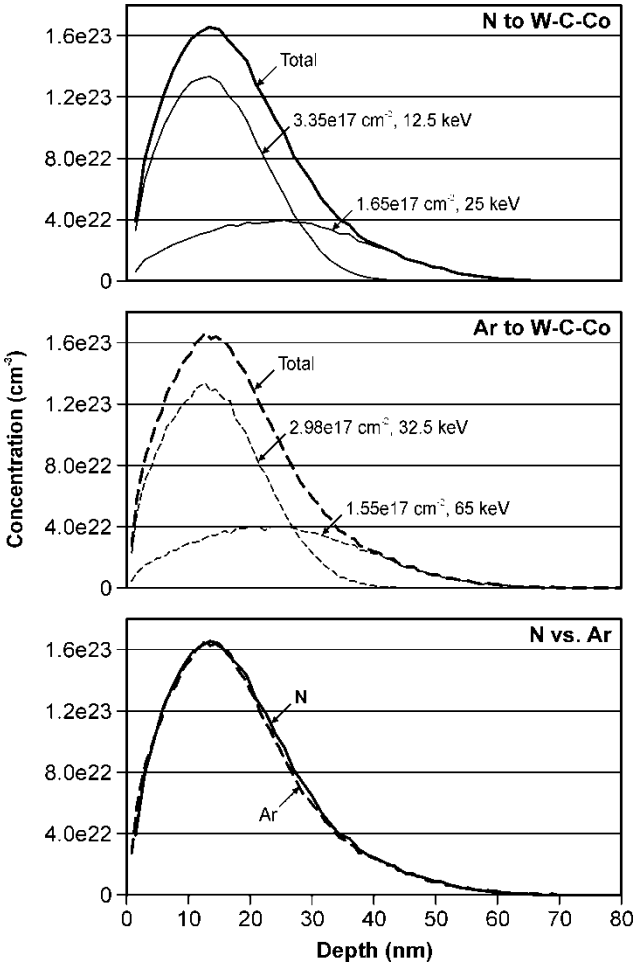

Figure 1. The modelling results of the similar depth profiles of nitrogen and argon implanted in W-C-Co material

Conclusions

Modelling of the similar depth profiles for the implanted ions of two popular gases, used in laboratories and in industry, i.e. nitrogen and argon, was successful.

The next stage of the investigation will be a practical verification of the influence of similar nitrogen and argon depth profiles in the WC-Co substrate for its wettability.

The wettability of nitrogen and argon implanted WC-Co indexable knives used for wood-based material machining

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Introduction

Ion implantation used as a modification method of WC-Co tools for wood-based material machining can produce spectacular results. The observed tool durability usually increases by two times or more. Moreover, the variability of the tools, modified in this way decreases, which is advantageous from the viewpoint of their use in automated systems.

Wettability is a parameter, often used in description of the surface state of the modified materials. Therefore, it was decided to check a dependence of the wettability on the position of the depth profiles of the implanted elements.

Materials and Methods

Commercially available WC-Co composite indexable KCR08 type knives with dimensions of 29.5×12×1.5 mm^3, produced by Ceratizit Company (Reutte, Austria), commonly used in the furniture industry (presented in the upper right corner of Fig. 2), were used for the investigations. The surface opposite to the rake surface was polished manually for the half of the investigated tools, using Struers MD-Dac™ type polishing cloths (Polishing Cloths) and Struers DiaPro Allegro/Largo 9 type water based diamond suspension with diamond diameter of 9 μm (Diapro). Prior to the investigation, they were washed in high purity acetone under ultrasonic agitation for 15 min. at room temperature.

The roughness and other surface parameters were measured using Hommel-Tester T 2000 profilometer (Hommelwerke, Villingen-Schwenningen, Germany), for six places at the measured surface, in section length of 1 mm each.

The ion implantation processes were performed using, semi-industrial implanter of gaseous ions, with non-mass separated ion beam, operated by the National Centre for Nuclear Research Świerk (Otwock, Poland).

Four sets of the WC-Co indexable knives, each including two initial and two polished knives, were implanted in the modelled conditions, at the room temperature.
The base pressure in the vacuum chamber was at a level of about 8e-4 Pa (8e-6 mbar). Nitrogen and argon of 5N purity were used as the source of the implanted gaseous ions. The implanted fluence was at a level of 3e17 cm^{-2}.

The static contact angle measurements, using sessile drop method, were provided for six spots on each un-implanted and implanted (initial, i.e. as supplied by the manufacturer and polished) knife, at room temperature, using a tester, supported by Surfaceware 9 code (SURFACEWARE). This program automatically determines the base of the drop, its outline

and two tangents and generates an analysis report, which includes among others the values of: average contact angle, left and right contact angle values, drop volume, wetting energy, work of adhesion.

Results

The average measurements results of the contact angle, the calculated results of the relative index (the contact angle values obtained for implanted surfaces compared to the values for un-implanted surfaces) and the coefficients of variation (the indicator, combining average wettability and variability in the wettability) are presented in Fig. 1. The bars for the similar depth profiles, i.e. for the cases of 25 kV nitrogen and 65 + 32.5 kV argon, are outlined in the all graphs, for better visualization.

All values of the contact angle are smaller for the implanted surfaces (for the same surface preparation), both for initial and polished indexable knives.

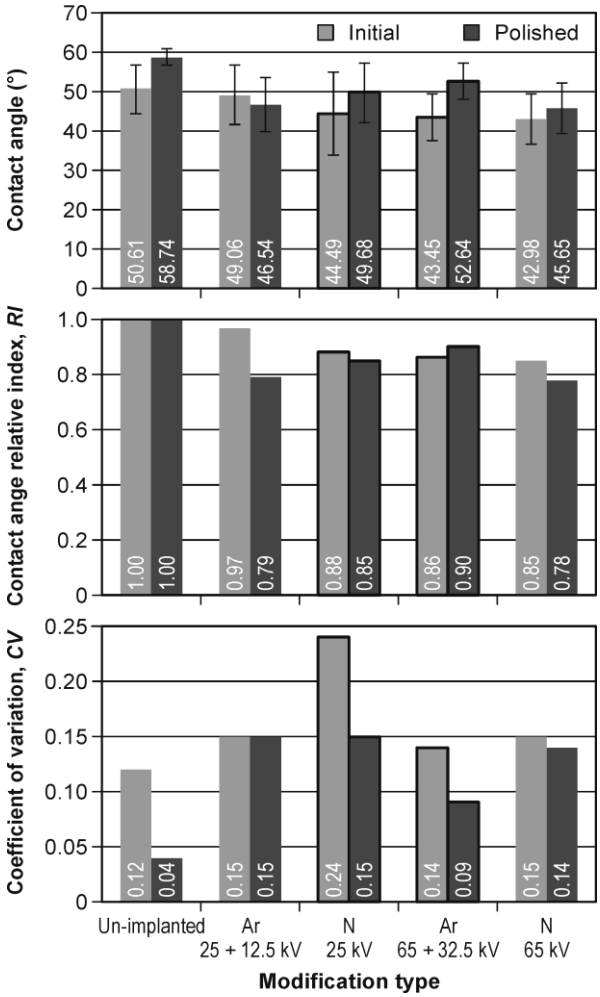

Figure 1. The values of the contact angle, the relative index and the coefficient of variation for un-implanted WC-Co knives and for the knives implanted with nitrogen and argon

Conclusions

Based on the presented results, it can be concluded, that the ion implantation causes a decrease in the contact angle, regardless of the surface roughness. The differences between the average values of the contact angle are not statistically significant due to the variability, but the decrease in the average values is obvious.

The application of recycled polymer in the impregnation and strengthening of wood-based panels.

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Wood-based panels, such as particleboards and MDF, consist of shredded wood of different morphologies, thermosetting glue and additives, which include hardeners, hydrophobic agents, paints, etc. Appropriately selected additives aim to improve the mechanical properties of the wood-based panels and impregnate the cellulose fibres against moisture and direct contact with water. In order to achieve this objective, a novel and yet unexplored recycled polymer, namely polyvinyl butyral (PVB), is incorporated into wood-based composites. PVB is a polymer that finds widespread application in the field of safety glass technology. It is often employed as an intermediate layer, serving as an adhesive, in various automobile glazing applications, burglar-proof glass, windows, balustrades, and even solar panels. Due to its structure, it has very good adhesive properties, not only to glass, but also to other materials including cellulose - wood and paper. Additional characteristics of PVB include flexibility, high impact energy absorption, UV resistance, noise dampening and excellent thermoplastic properties at low temperatures.

The research work proposed the addition of a recycled PVB solution of 0.5 to 2 %wt. instead of the commercially used impregnating agent, paraffin emulsion. A commercial urea-formaldehyde resin, UF, was used as a binder in the panels. As a first step, the mechanical tests of the fabricated panels with the PVB additive, i.e. the bending strength (MOR) and modulus of elasticity (MOE), were performed and compared with the panels without the additive as well as with the addition of the paraffin emulsion. Significant improvements in mechanical properties and an increase in bending strength were obtained with an increase in PVB addition. Important parameters for wood-based materials are the water absorption and swelling of the wood-based panels as a result of contact with water. The study confirmed that with increasing amounts of PVB additive, a significant reduction in the water absorption is achieved, as well as less swelling after 2 and 24 h of water contact compared to the board without the additive, as well as to the board with the paraffin emulsion additive. The use of PVB polymer also has a positive effect on reducing formaldehyde, HCHO emissions from urea-formaldehyde resin bonded panels. The addition of 2 %wt. PVB reduces HCHO emissions nearly twice, from 3.5 mg/(m2h) for the panel without the additive to 1.8 mg/(m2h) for the panel with the PVB additive.

The availability of PVB polymer from recycled glass laminate processes, the positive results of mechanical testing, the water absorption, swelling and formaldehyde emission reduction of wood-based panels indicate that PVB can successfully replace commercial paraffin emulsion obtained from heavy crude oil fractions, and that the reuse of PVB polymer fits into a closed-loop economy model.