



BOOK OF ABSTRACTS

**6th International Scientific
Conference
WOOD TECHNOLOGY
&
PRODUCT DESIGN**

**13th – 15th September, 2023
University Congress Centre,
OHRID, NORTH MACEDONIA**

**Ss. Cyril and Methodius University in Skopje
Faculty of Design and Technologies of Furniture and
Interior – Skopje, Republic of North Macedonia**





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WOOD TECHNOLOGY & PRODUCT DESIGN

**13– 15 SEPTEMBER, 2023
UNIVERSITY CONGRESS CENTRE – OHRID
REPUBLIC OF NORTH MACEDONIA**



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**WOOD TECHNOLOGY
& PRODUCT DESIGN**
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**THE EFFECT OF WOODEN MATERIAL TYPE AND ADDITIONAL
ADHESIVE FORTIFICATION ON THE WITHDRAWAL CAPACITY
OF THE DOUBLE-THREAD NUTS**

**Alen Ibrisevic¹, Seid Hajdarevic¹, Murco Obucina¹,
Ibrahim Busuladzic¹, Goran Mihulja²**

¹ *Department of Wood Technology, Faculty of Mechanical Engineering Sarajevo,
University of Sarajevo, Sarajevo, Bosnia and Herzegovina
e-mail: ibrisevic@mef.unsa.ba; hajdarevic@mef.unsa.ba; obucina@mef.unsa.ba;
busuladzic@mef.unsa.ba*

² *Department of Wood Technology, Faculty of Forestry and Wood Technology
University of Zagreb, Zagreb, Croatia
e-mail: gmihulja@sumfak.hr*

ABSTRACT

The construction of furniture is often carried out by assembling double-thread nuts. During exploitation, furniture is exposed to various forces that cause it to pull out double thread nuts and damage the strength of the structure. This study aimed to investigate the effect of wooden material type and adhesive type on the withdrawal capacity of double thread nuts. For this purpose, an experimental design that consisted of one type of double thread nuts with diameter of 7, and length of 13 mm were used with in 3 types of wooden materials (beech, medium density fibreboard and particleboard) and 4 adhesives. An analysis of variance (ANOVA) was performed to evaluate the impact of wood materials as well as their fortification with different adhesives. The results showed that the best results are obtained with beech wood fortified with polyurethane adhesive. The lowest results are obtained in particleboard fortified with polyvinyl acetate mounting D2 glue.

Keywords: *withdrawal capacity, double thread nuts, wooden materials, adhesives*

THE SOUND SIGNAL PROCESSING AND DEEP LEARNING NETWORK AS A TOOLS FOR DETERMINING THE CIRCULAR SAW BLADE SPEED

Srdjan Svrzi¹, Mladen Furtula¹, Marija Turkovi¹,
Vladislava Mihailovi¹, Aleksandar Dedi¹

¹University of Belgrade, Department of Wood Science,
Faculty of Forestry, Belgrade, Serbia
e-mail: srdjan.svrzic@sfb.bg.ac.rs

ABSTRACT

Rotation of a saw blade presents one of the most important cutting parameter, often regarded as cutting speed. The purpose of this paper was to determine the discrete values of the circular saw blade speed by means of the deep learning network. During idle rotation of the saw blade certain sounds are produced which were recorded and later processed in Matlab software making them suitable for further analysis and training the deep learning network. For the chosen values of the circular saw blade rotational speed, set at 2000, 3000 and 4000 rpm, totally 600 recordings were made (200 for each speed) in the form of wave format. All of them were converted in power spectrum by Fast Fourier Transformation (FFT) in order to determine spectral areas of the most importance, and later the spectrograms were made using Short Time Fourier Transform (STFT), as magnitude squared of STFT. The obtained spectrograms formed the data base for training and testing deep learning network. Pre-trained network shows the accuracy of 100%.

Keywords: *sound signal, signal processing, FFT, SFFT, spectrogram, deep learning, machine learning*

IMPACT OF FEED RATE ON ROUGHNESS OF THE CUT SURFACE, DURING CUTTING DRY BEECH WOOD WITH A CIRCULAR SAW

Anastasija Temelkova

*Ss. Cyril and Methodius University in Skopje, North Macedonia,
Faculty of design and technologies of furniture and interior-Skopje
e-mail: temelkova@fdtme.ukim.edu.mk*

ABSTRACT

The feed rate during mechanical processing of wood is one of the factors that has a high influence on the roughness of the cut surface. The roughness of the cut surface caused by traces of the cutting tool (the main and secondary blades of the teeth) has an influence on the hydrothermal treatment and all other mechanical treatments of the wood. Greater roughness, due to faster evaporation of moisture from the wood, increases the percentage of drying errors. On the other hand, higher roughness reduces the utilization rate of the wood. For this purpose, in this paper, the dependence of the feed rate on the roughness of beech wood during cutting of dry wood with a circular saw is investigated, with the intention of determining the optimal cutting conditions for obtaining lower values of the roughness. In this research, three different feed rates were applied ($U_1=12 \text{ mmin}^{-1}$, $U_2=16 \text{ mmin}^{-1}$ and $U_3=20 \text{ mmin}^{-1}$) for a constant cutting height of 45 mm in dry beech wood with humidity $W=10\pm 1\%$. The measurements were made with a circular saw with diameter of $D=250 \text{ mm}$, number of teeth $Z=40$ and width of the cut $b=3,2 \text{ mm}$. The number of revolutions is $n=5500 \text{ min}^{-1}$. Roughness measurements were taken with a digital comparator, according to the R_{\max} criterion. The obtained results show a pronounced significance, i.e. directly proportional dependence of the roughness of the cut surface on the feed rate.

Keywords: *beech wood, circular saw, roughness, the feed rate*

DEVELOPMENT OF DISCOLORATION DURING CONVENTIONAL DRYING OF OAK TIMBER

Bogdan Bukara¹, Goran Mili²

¹*Gir ltd, Adrani - Kraljevo, Republic of Serbia
e-mail: bogdan.bukara@gir.rs*

²*University of Belgrade – Faculty of Forestry,
Department of Wood Science and Technology,
Belgrade, Republic of Serbia
e-mail: goran.milic@sfb.bg.ac.rs*

ABSTRACT

This research aimed to examine the development of inhomogeneous colour changes in oak timber during conventional drying and its relation to moisture content distribution across the wood thickness. To explore this phenomenon, control boards (quarter-sawn and flat-sawn, 38 mm thick) were cut from two oak logs, one of the Sessile oak (*Quercus petraea*) and one of the Pediculate oak (*Quercus robur*). The control boards were dried in a conventional kiln according to the common drying schedule, and at specific time intervals, samples were taken to determine the moisture content profile. During each cutting of the samples, the appearance of discoloration was controlled. The results of the study revealed that there is a connection between the moisture content distribution within the boards and the appearance of discoloration. Furthermore, it was found that Sessile oak timber dries more slowly and with less intense discolourations than Pediculate oak timber. It is confirmed that quarter-sawn boards dry slower compared to flat-sawn boards and this applies to both wood species.

Keywords: *conventional drying, oak timber, discolouration, moisture content profile*

ANALYSIS OF THE INFLUENCE OF CONSUMERISM ON THE EPHEMERALITY OF THE INTERIORS OF PUBLIC FACILITIES

Edona Arifi Sadiku

*Ss. Cyril and Methodius University in Skopje, Macedonia,
Faculty of Design and Technologies of Furniture and Interior-Skopje,
e-mail:edona.arifi@gmail.com*

ABSTRACT

The purpose of this paper is the verification of the indications of consumerism and architecture, concisely in the sphere of interiors for trade and sales. Furthermore, are analyzed and detected the properties of consumerism, who contribute directly and indirectly through the social factor to ephemerality in architecture, interiors and design.

Consumerism in the period of postmodernism, as a more specific research area of this paper, is an immanent phenomenon. The social-economic conditions determined by the social conditions indicate a strong rise of consumerism in more significant spheres of human life, especially and undoubtedly in the spheres that are connected to direct profit, such as public interiors with sales activity. Architecture and interior design are applicative multidisciplinary sciences, always under the influence of political, sociological and economic developments. Today's post-industrial period – the rapid development of technologies and materials, fast and unlimited production, leads to endless consumption and changes in the appearance of the product, thereby indirectly and directly to changing the architecture and design in public facilities. Ephemeral architecture and design becomes the key answer. Through the research of commercial public facilities - from the City Trade Center to some newer shopping centers in R. N. Macedonia, in this paper is practically reached to conclusions which characteristics, processes and influences of consumerism as a phenomenon, have contributed to today's appearance in the architecture and design of public commercial buildings, over the years.

Through architectural recording, analysis and comparison of existing interiors, the ways and methods of organizing the public interior are clarified, which in conditions of frequent consumerism become ephemeral-temporary, transient, short-lived.

Keywords: *Social - economic conditions, cultural - social conditions, consumerism, internationalism, ephemerality, interior, architecture, design, furniture, commercial facilities*

ASSESSING SEAR STRAIN DISRIBUTION IN WOOD UNDER IMPACT USING DIGITAL IMAGE CORRELATION METHOD

Mojtaba Hassan Vand, Jan Tippner

*Mendel University in Brno, Czech Republic
Faculty of Forestry and Wood
e-mail: xhassanv@mendelu.cz*

ABSTRACT

The growing demand for biobased materials across various industries necessitates a comprehensive study of the high-rate loading effects on wood. While the 3-point impact bending test is commonly employed for evaluating material behavior under high-rate loadings, determining the strain distribution of the specimen remains challenging due to the rapid nature of impact and the need for specialized equipment and methods. Additionally, wood's heterogeneous nature and orthotropic structure make it difficult to identify the location of the highest shear strain. This research explores the potential of digital image correlation methods to ascertain the shear strain distribution in a wooden beam subjected to impact. The study determined the maximum shear strain in ash wood (*Fraxinus excelsior* L.) test samples and investigated the progressive pattern of shear strain during impact. The results demonstrate that, with appropriate equipment, the digital image correlation method can effectively determine the shear strain distribution during impact loading.

Keywords: *impact loading, shear strain, digital image correlation method*

INFLUENCE OF THERMAL MODIFICATION SCHEDULES ON THE NATURAL WEATHERING OF MAPLE AND ASH WOOD

Marko Veizovi ¹, Goran Cvjeticanin¹, Nebojša Todorovi ¹, Goran Mili ¹

¹University of Belgrade – Faculty of Forestry,
Department of Wood Science and Technology,
Belgrade, Republic of Serbia

e-mail: marko.veizovic@sfb.bg.ac.rs; goran.cvjeticanin@sfb.bg.ac.rs;
nebojsa.todorovic@sfb.bg.ac.rs; goran.milic@sfb.bg.ac.rs

ABSTRACT

This study aimed to compare the influence of two thermal modification (TM) schedules — with short (65 h) and long (112 h) heating phases — on the natural weathering of maple (*Acer pseudoplatanus* L.) and ash (*Fraxinus excelsior* L.) wood. Over a duration of almost 21 months (October 2021 – June 2023), the changes in wood colour, density and moisture content (MC) were monitored. The samples were exposed to all weather conditions facing south, positioned 1 m above ground level under a 45-degree slope with horizontal grain orientation. At the end of the experiment, the water absorption of weathered and non-weathered samples was compared. During the process of weathering, a pronounced alteration in the inherent colouration of the control and TM samples (both schedules) was observed in both wood species. At the end of the weathering process, the colour of all samples, whether treated or untreated, had reached a similar appearance. Surface checks were more present in ash compared to maple wood, particularly in samples with wider growth rings. During the initial phase of the experiment (first winter - from October '21 to March '22), MC variations were more pronounced, but the extent of these changes diminished with time. The control samples were found to be the most responsive to weather condition changes, while TM (fast schedule) samples exhibited slightly higher MC variations compared to samples modified under a slow schedule.

Keywords: weathering, thermal modification schedule, maple, ash wood

**THE INFLUENCE OF COMPUTER SOFTWARE INTENDED FOR
CONSTRUCTIVE PREPARATION ON THE TIME FOR THE PRODUCTION
OF THE NECESSARY TECHNICAL DOCUMENTATION IN A MICRO-
ENTERPRISE FOR THE PRODUCTION OF CUSTOM-MADE FURNITURE**

Marija Krstev

*Ss. Cyril and Methodius University in Skopje, Macedonia,
Faculty of Design and Technologies of Furniture and Interior-Skopje,
e-mail:ilievska_11@yahoo.com*

ABSTRACT

The research presented in this paper is part of an ongoing research intended for the preparation of the author's PhD dissertation. Its purpose is to see the impact of computer software intended for constructive preparation, on the time required to prepare the complete technical documentation during the launch of a new product within a micro enterprise for the production of custom-made panel furniture.

For that purpose, the time spent during standard constructive preparation was measured by drawing views, sections and details in AutoCAD of previously prepared 3D models of various pieces of furniture, and then dimensioning the constituent elements and creating a scheme for cutting the material in an appropriate software.

For the same pieces of furniture, time was measured during the preparation of the same documentation through several different software intended for constructive preparation, specifically in Corpus5 in the first part of the research, as well presented in this paper.

The results are showing that the computer software significantly shortens the constructive preparation time when we use ready-made pieces of furniture that already exist in their database.

Keywords: *computer software, corpus, constructive preparation, custom-made*

**PARAMETER DETERMINATION AND PERFORMANCE COMPARISON
OF THE RHEOLOGICAL MODELS FOR
CREEP IN PARTICLEBOARD**

**Mira Miri -Milosavljevi¹, Vladislava Mihailovi¹,
Marija Jurkovi¹, Srđan Svrzi¹**

*¹University of Belgrade Faculty of Forestry Serbia
e-mail: mira.miric-milosavljevic@sfb.bg.ac.rs;
vladislava.mihailovic@sfb.bg.ac.rs; marija.djurkovic@sfb.bg.ac.rs;
srdjan.svrzic@sfb.bg.ac.rs*

ABSTRACT

Rheological model presents relationship between the stress and the strain in material throughout entire exploitation period. The change of the properties of a stressed and strained material in the time domain could be assessed on the basis of the rheological model.

This paper is focused on determination of the model parameters and comparison of several rheological models for particleboard coated with melamine foil. The 18 millimeters thick particleboard samples with dimensions 800 x 300 mm (which are dimensions of larger book shelves) were loaded with uniformly distributed load.

The model parameters were defined for four models: purely mathematical power-law, two viscoelastic – Zener (Standard Linear Solid) three-parameter and Burger four-parameter model, as well as semi empirical five-parameter (modified Burger) model. The performance of models was compared in two ways: (i) according to the fit to the experimental data and (ii) according to the better total strain prediction.

The differences in predicted strain values, which were calculated on the basis of models applied, indicate the possibility of large errors even in the cases where the model was well fitted to experimental results.

Keywords: *rheological model, viscous creep, particleboard*

**PROCEDURE OF OPTIMIZING SOLID OAK WOOD (*Quercus robur* L.)
BENDING PROCESS IN FURNITURE MANUFACTURE**

Mislav Mikšik¹, Stjepan Pervan¹, Silvana Prekrat¹, Mladen Brezovi¹

¹*University of Zagreb, Zagreb, Republic of Croatia,
Faculty of Forestry and Wood Technology,
e-mail: mmiksik@sumfak.unizg.hr; pervan@sumfak.unizg.hr;
sprekrat@sumfak.unizg.hr; mbrezovic@sumfak.unizg.hr*

ABSTRACT

Solid wood bending is the type of processing with certain levels of mechanical destruction. Higher material utilization, small investments in technology, high strength and stiffness of bent wood elements, and uniformity of structure in furniture parts are some advantages of wood bending. Sawn elements have their grain slope cut off in certain parts which lowers the strength and load-bearing capacity of the final piece of furniture contrary to continuous grain slope in bent counterparts.

In this research procedure of optimization of solid oak wood bending (*Quercus robur* L.) process in furniture manufacture will be explained. All the challenges encountered while attempting to optimize bending process by using combination of steaming and drying with high frequency (HF) will be described and explained. Utilization comparisons at the beginning of process and after optimizing it including current state will be presented.

Keywords: oak (*Quercus robur* L.), solid wood, bending, high frequency, steaming

PANEL SHEAR PROPERTIES OF CARBON FIBER REINFORCED LVL BOARD

Neda M. Sokolovi¹, Ivana Gavrilovi -Grmuša², Nenad Šekularac¹

¹Faculty of Architecture, University of Belgrade, 11000 Belgrade, Serbia

²Faculty of Forestry, University of Belgrade, 11000 Belgrade, Serbia

e-mail: neda.socolovic@arh.bg.ac.rs

ABSTRACT

Problem of rational use and lack of quality wood raw material for producing veneer boards, can be solved using poor quality wood raw materials for design composite veneer board. Poplar LVL panels do not have structural use because of its mechanical properties. Fiber reinforced composites can improve mechanical properties of wood-based panels, and thus enable the structural use of poplar panels. Synthetic fibers can reinforce panels, minimize the negative properties of wood raw material and improved dimensional stability of the board. This paper presents the results of experimental testing of the panel shear tests of unreinforced and reinforced seven-layer LVL (laminated veneer lumber) poplar veneer panels. The aim of the research is to determine the influence of woven carbon fibers on the improvement of the panel shear test of LVL, in order to test the potential of using this composite material as a structural element. The orientation of fibers has a strong influence on the reinforcement. The main research task is investigation the effects of orientation of the carbon fibers and their position in the panel construction on the shear properties of the panel. This research present possibility of applying poplar veneer to design structural elements in LVL using epoxy adhesive.

Keywords: carbon fiber fabric, mechanical properties, laminated veneer lumber, CFRP, reinforcement; epoxy adhesive

LOADBEARING STRUCTURES FROM RECLAIMED WOOD-STRATEGIES, DESIGN PARAMETERES AND REFLECTIONS

Olga Popovic Larsen¹, Xan Browne¹

¹*Royal Danish Academy: Architecture, Design, Conservation, Institute for Architecture and Technology, Copenhagen, Denmark,
e-mail: Olga.Larsen@kglakademi.dk; xbro@kglakademi.d*

ABSTRACT

It is a well-known fact that the building sector is one of the largest polluting and CO₂ emission contributing sectors. In addition, what Nature has created over milenia as material resources is used up very fast with some materials already becoming scarce. The climate emergency we are facing calls for better and more sustainable approaches for the building sector.

This is the motivation and starting point for this paper that presents three different strategies for building loadbearing structures in wood. Through three full-scale prototypes we put forward strategies, design parameters and reflections about the opportunities and challenges of utilizing second-hand wood for loadbearing structures. The three projects all seek to investigate the viability of wood cascading, giving wood a longer life in its solid form by offering a load-bearing structural design that can be reused several times. Furthermore, *The ReciPlyWood*, *Waste Wood Pavilion* and the *Wood ReFramed* test different strategies for structural safety through robustness as well as simple connection systems. Optimising usability, buildability, and aesthetics and waying them out has been important in all three projects. The paper ends with a reflection of the process and results and points to steps needed for wood to be accepted as a multigenerational material for load-bearing structures.

Keywords: *wood cascading, reclaimed wood loadbearing structures, full-scale prototypes*

CURRENT STATE OF THE WOODEN TOYS MARKET IN SERBIA AND THE FACTORS SLOWING DOWN ITS DEVELOPMENT

Slavica Petrovi

*University of Belgrade, Serbia, Faculty of Forestry,
e-mail:slavica.petrovic@sfb.bg.ac.rs*

ABSTRACT

The research presents the results of a study of the wooden toys market in Serbia. In the past few years, there has been a noticeable trend of growth in wooden toys production on the market in Serbia. The products include all types of wooden toys, ranging from classic and educational toys to social games. It was expected, that the growth of production would follow the growth of export of these products, especially to the markets of EU countries where there is a high demand for these ecological products. However, although high quality wooden toys that are produced in Serbia are innovative and attractive, the most important foreign markets for the placement of these products are non-EU countries surrounding Serbia. Therefore, the primary aim of this research was to identify the main barriers to the placement of wooden toys produced in Serbia on the markets of EU countries. The research also aimed to identify the countries from which Serbia imports wooden toys the most, as well as the value of these imports.

Keywords: *wood, toys, trade, market, regulation*

ADHESION STRENGTH OF COATINGS ON WOOD

Tanja Palija

*University of Belgrade, Faculty of Forestry, Serbia
e-mail: tanja.palija@sfb.bg.ac.rs*

ABSTRACT

In wood surface finishing coatings present the basic material that is used to protect the surfaces of the final wood products, while preserving or improving its aesthetic characteristics. The coating market is constantly evolving offering improved coatings formulations in terms of environmental eligibility and/or decorative and protective properties. However, the upgraded characteristics of chosen coatings does not mean much if an adequate adhesion between the coatings and the substrate is not achieved. For this reason, the adhesion strength of coating can be considered a key parameter of the quality of a coated wood surface.

This paper explores the possibilities and limitations of different methods of testing the adhesion strength of the coatings on the wood surface.

Further, the impact of the properties of the coated system components (substrate and coatings), both native and the ones that are result of different surface finishing operations (preparation of the substrate, staining, application and drying of the coatings) on the adhesion strength of coatings on wood, was analyzed.

Keywords: *adhesion strength, wood, coatings*

HARDNESS OF PLYWOOD REINFORCED WITH FIBERGLASS PREPREG

Violeta Jakimovska Popovska¹, Borche Iliev¹

¹ Ss. Cyril and Methodius University in Skopje, R. of North Macedonia,
Faculty of design and technologies of furniture and interior-Skopje
e-mail: jakimovska@fdtme.ukim.edu.mk, iliev@fdtme.ukim.edu.mk

ABSTRACT

Improvement of plywood properties can be done by reinforcing plywood with non-wood materials in their structure.

The aim of this research is to study the Janka hardness of plywood reinforced with fiberglass prepreg sheets inserted in plywood structure. These reinforcement sheets are made of fiberglass fabric that is pre-impregnated with phenol-formaldehyde resin. Plywood is consisted of eleven veneer sheets with thickness of 1,5 and 1,85 mm that are bonded with the same resin used for fiberglass fabric pre-impregnation.

By changing the position of fiberglass prepreg sheets in plywood structure, four different models of plywood were made.

Tests for plywood hardness according to Janka were done on each plywood model.

The obtained results showed that the values of Janka hardness are affected by the use of fiberglass prepreg sheets in plywood structure.

Keywords: *plywood, reinforcement, fiberglass, prepreg, pre-impregnated, phenol-formaldehyde resin, Janka hardness*

IN-PLANE COMPRESSIVE STRENGTH OF PLYWOOD REINFORCED WITH COTTON PREPREG

Violeta Jakimovska Popovska¹, Borche Iliev¹

¹ Ss. Cyril and Methodius University in Skopje, R. of North Macedonia,
Faculty of design and technologies of furniture and interior-Skopje
e-mail: jakimovska@fdtme.ukim.edu.mk, iliev@fdtme.ukim.edu.mk

ABSTRACT

The aim of this research is to study the in-plane compressive strength of eleven-layered beech plywood reinforced with non-wood material in its structure.

Plywood reinforcement was made by inserting certain numbers of sheets of pre-impregnated cotton fabric (cotton prepreg). Methyl alcohol soluble phenol-formaldehyde resin was used for fabric pre-impregnation, as well as for veneer bonding. The thickness of the veneers used in plywood structure was 1,5 and 1,85 mm.

Different models of plywood were made by changing the position of cotton prepreg reinforcements in plywood structure. One control model of plywood without reinforcement was made.

In-plane compressive strength of plywood models was tested in five directions: parallel to the face grain, perpendicular to the face grain, at the angles of 22,5°, 45° and 67,5° to the face grain of the plywood panel.

The obtained results showed that the application of cotton prepreg in plywood structure has impact on the values of in-plane compressive strength of plywood.

Keywords: *plywood, reinforcement, cotton fabric, prepreg, pre-impregnated, phenol-formaldehyde resin, compressive strength*

BENDING STRENGTH AND MODULUS OF ELASTICITY IN BENDING OF BEECH AND BLACK PINE PLYWOOD

Violeta Jakimovska Popovska¹, Borche Iliev¹

¹ *Ss. Cyril and Methodius University in Skopje, R. of North Macedonia,
Faculty of design and technologies of furniture and interior-Skopje
e-mail: jakimovska@fdtme.ukim.edu.mk, iliev@fdtme.ukim.edu.mk*

ABSTRACT

The research presented in this paper includes the study of bending properties of plywood made from beech and black pine veneers. For this purpose, four experimental plywood models were made. Two of the models were made from peeled beech and other two models were made from peeled black pine veneers. Water-soluble phenol-formaldehyde resin was used as plywood binder.

The bending strength and modulus of elasticity in bending of the experimental plywood were tested in two directions, parallel and perpendicular to the face grain.

According to the values of bending strength and modulus of elasticity in bending, plywood models can be used for structural application in construction. Production of plywood with different number of veneers in panel structure, as well as plywood with the same number of the veneers but from different wood specie, gives opportunities for production of panels that can meet different application requirements.

Keywords: *plywood, veneer, beech, black pine, phenol-formaldehyde resin, bending strength, modulus of elasticity in bending*

THE INFLUENCE OF THE QUALITY OF POPLAR LOGS ON THE YIELD IN THE PRODUCTION OF VENEER PACKAGING

Aleksandar Lovri¹, Vladislav Zdravkovi¹,
Nebojša Todorovi¹, Stefan Milovanovi²

¹University of Belgrade – Faculty of Forestry
e-mail: aleksandar.lovric@sfb.bg.ac.rs;
vladislav.zdravkovic@sfb.bg.ac.rs; nebojsa.todorovic@sfb.bg.ac.rs
²stefanmilovanovic92@gmail.com

ABSTRACT

Poplar logs of F, L, I and II quality classes were used in the research. The logs are first cut to the appropriate size and then rotary peeled into standard elements for veneer packaging. According to the results of the research, a significantly higher quantitative utilization (71.93% and 75.55%) was obtained with F and L class logs compared to quality class I and II logs (58.83% and 53.69% respectively). However, according to the corrected coefficients of economic profitability of processing, it was the least profitable to process logs of F class, followed by class I and finally class II, while logs of class L were the most profitable for processing.

Keywords: *poplar, wooden crates for packaging, quantitative utilization and financial effect*

DETERMINATION OF THE HEAT ENERGY FOR HYDROTHERMAL TREATMENT OF ASHWOOD (*Fraxinus excelsior*) BY LOG SOAKING

Ana Marija Stamenkoska¹, Goran Zlateski¹

¹Ss. Cyril and Methodius University in Skopje, North Macedonia,
Faculty of Design and Technologies of Furniture and Interior-Skopje
e-mail: stamenkoska@gmail.com; zlateski@fdtme.ukim.edu.mk

ABSTRACT

The treatment of logs by soaking is a complex technological and thermal procedure, in which logs and prisms are used as raw material for the production of peeled and sliced veneers. Such treatment of logs is carried out in pools or pits constructed in the ground. By log soaking two significant changes to the wood are achieved, its coloring and the inevitable plastification of the wood fibers. During this procedure, the time required for air drying is significantly reduced. The soaking medium is freshwater or previously used water at an elevated temperature. This soaking treatment is particularly suitable for logs for the production of peeled and sliced veneer, from which resin must be removed. Soaking is also used when treating wood species that are sensitive to steaming.

This paper provides an analysis of the thermal energy required for hydrothermal treatment by log soaking of ashwood (*Fraxinus excelsior*). The logs were intended for the production of peeled veneer. The log treatment was done in a reinforced concrete pool built in the ground. The total amount of heat for log soaking (Q) consists of effective heat (Q_e) and heat loss (Q_l). The procedure was conducted by the strong treatment mode, with a temperature interval in the range of 70 to 90 °C. The treated logs had a minimum mean diameter of 35.0 cm and a minimum length of 1.8 m. Log soaking was used as a method for defrosting of the logs, due to their low initial temperature, which was – 15 °C.

Keywords: hydrothermal treatment, log soaking, temperature, heat energy, effective heat, heat loss

WOOD WASTE IN THE SAWMILL INDUSTRY OF WOOD PROCESSING

Ana Marija Stamenkoska¹, Goran Zlateski¹

¹*Ss. Cyril and Methodius University in Skopje, North Macedonia,
Faculty of Design and Technologies of Furniture and Interior-Skopje
e-mail: stamenkoska@gmail.com; zlateski@fdtme.ukim.edu.mk*

ABSTRACT

Sawmill processing produces a certain amount of waste, as a result of processing sawlogs into sawn lumber. Waste occurs in the form of fine and coarse waste. Fine and coarse waste are generated on the primary milling machine (band saw) and on the circular saws for transversal and longitudinal lumber cutting. In addition to fine and coarse waste, sawdust also occurs as waste, but due to its specificity, it is not quantified.

This paper presents results obtained from several years of research, conducted in five sawmill capacities. The researched capacities were at the territory of the Republic of North Macedonia. The data was gathered under manufacturing conditions.

The wood species covered in the paper are beech (*Fagus sylvatica* L.), pine (*Pinus sylvestris*, *Pinus nigra*), oak (*Quercus sessiliflora*), aspen (*Populus tremula* L.) and fir/spruce (*Abies alba/Picea excelsa*). The results indicate that beech has the highest percentage of total waste, and fir/spruce has the lowest percentage of total waste.

Keywords: *processing, lumber, sawmill, wood waste, fine and coarse waste, relative values*

LIGNOCELLULOSE COMPOSITION, PROXIMATE ANALYSIS AND HEAT VALUE OF CERTAIN FOREST AND ENERGY CROP BIOMASSES AND THEIR POTENTIAL AS RAW MATERIALS FOR THE PRODUCTION OF SOLID BIOFUELS

**Božidar Matin¹, Ana Matin², Ivan Brandi², Alen Aurović¹,
Josip Ištvani¹, Alan Antonović¹**

¹University of Zagreb, Faculty of Forestry and Wood Technology, Zagreb, Croatia
e-mail: bmatin@sumfak.hr; aurovic@sumfak.hr; jistvanic@sumfak.hr;
aantonovic@sumfak.hr;

²University of Zagreb, Faculty of Agriculture, Zagreb, Croatia
e-mail: amatin@agr.hr; ibrandic@agr.hr

ABSTRACT

Biomass as a raw material is available in large quantities and inexpensive. Its renewable energy can reduce greenhouse gas emissions, and it depends primarily on the composition of lignocellulose, especially the lignin content. Forest biomass of oak and beech, as well as biomass of energy crops *Miscanthus giganteus* and *Panicum virgatum* were used for this study. The aim of the study was to determine the lignocellulosic composition (proportions of cellulose, lignin, hemicellulose), proximate analysis (proportions of moisture, ash, coke, fixed carbon, volatiles) and calorific value of the studied biomasses, as well as to examine the possibility of their use as raw materials for the production of solid biofuels. The research showed that both forest biomass and biomass of energy crops have favorable values of the analyzed parameters, which is best reflected in the excellent calorific value, ranging from 17 to 18.5 MJ/kg. It was also found that the studied samples are ideal raw materials for the production of solid biofuel with lignin content between 20 and 30%.

Keywords: forest biomass, energy crops, lignocellulose, proximate analysis, calorific value, solid biofuel

IMPACT OF FEED RATE ON ROUGHNESS OF THE CUT SURFACE, DURING CUTTING DRY SPRUCE WOOD WITH A CIRCULAR SAW

Anastasija Temelkova

*Ss. Cyril and Methodius University in Skopje, North Macedonia,
Faculty of design and technologies of furniture and interior-Skopje
e-mail: temelkova@fdtme.ukim.edu.mk*

ABSTRACT

The feed rate during mechanical processing of wood is one of the factors that has a high influence on the roughness of the cut surface. The roughness of the cut surface caused by traces of the cutting tool (the main and secondary blades of the teeth) has an influence on the hydrothermal treatment and all other mechanical treatments of the wood. Greater roughness, due to faster evaporation of moisture from the wood, increases the percentage of drying errors. On the other hand, higher roughness reduces the utilization rate of the wood. For this purpose, in this paper, the dependence of the feed rate on the roughness of spruce wood during cutting of dry wood with a circular saw is investigated, with the intention of determining the optimal cutting conditions for obtaining lower values of the roughness. In this research, three different feed rates were applied ($U_1=12 \text{ mmin}^{-1}$, $U_2=16 \text{ mmin}^{-1}$ and $U_3=20 \text{ mmin}^{-1}$) for a constant cutting height of 45 mm in dry spruce wood with humidity $W=10\pm 1\%$. The measurements were made with a circular saw with diameter of $D=250 \text{ mm}$, number of teeth $Z=40$ and width of the cut $b=3,2 \text{ mm}$. The number of revolutions is $n=5500 \text{ min}^{-1}$. Roughness measurements were taken with a digital comparator, according to the R_{\max} criterion. The obtained results show a pronounced significance, i.e. directly proportional dependence of the roughness of the cut surface on the feed rate.

Keywords: *spruce wood, circular saw, roughness, the feed rate.*

SPATIAL FLEXIBILITY IN TRADITIONAL MACEDONIAN ARCHITECTURE FROM THE 19TH CENTURY

Branko Temelkovski

*Ss. Cyril and Methodius University in Skopje, North Macedonia
Faculty of Design and Technology of Furniture and Interior – Skopje,
PhD Student ,e-mail: branko.tt@gmail.com*

ABSTRACT

Intricate concepts of spatial organization characterize the traditional Macedonian architecture of the 19th century. The limitations imposed by specific materials and technological constraints during that era stimulated the development of intelligent and versatile spatial models. This research seeks to investigate the qualities of spatial flexibility and their practical application.

The study will commence by defining the concepts of flexibility and polyvalence of space as sustainable architectural properties. It will then systematically analyze these properties within traditional Macedonian architecture, focusing on elementary spatial units such as rooms, as well as communication spaces. The study will examine approximately 200 houses from this period. Finally, a comparative analysis will be conducted, drawing examples from contemporary architecture to illustrate these concepts further.

Keywords: *flexibility, polyvalence, spatial configuration, traditional architecture*

DESIGN OF HARDBOARD REINFORCED WITH NATURAL WOOL OF INDIGENOUS PRAMENKA SHEEP

Dejla Rami ¹, Atif Hodži ¹, Damir Hodži ¹, Hasan Tali ¹

*University in Biha , Bosnia and Herzegovina,
Faculty of Technical Engineering Biha ,
e-mail: dejla.ramic@unbi.ba, atif.hodzic@unbi.ba, damir.hodzic@unbi.ba,
hasan.talic@unbi.ba*

ABSTRACT

This paper is an output of research project and it presents design and making of hardboard reinforced with natural wool of indigenous Pramenka sheep. The goal of the project was to create hardboard with the addition of wool fibers. Hardboard is a high-density fiberboard, similar to plywood, but it is pressed under higher pressure and temperature, so it has greater hardness. Sawdust, waste from the production of boards, slats, beams are most often used for their production, i.e. all wood processing waste is used. Our idea was to add wool fibers to production in addition to waste. The sustainability of this initiative is reflected in the continuous production of wooden structures that contain a certain percentage of wool as an additional material. As wool is a material that is easily available and is currently of little use in our area, its application in the production of panel elements would ensure less waste and recycling of wool, while at the same time sustainability is not in question. This initiative can be an example because in previous research it is not known that this method of applying wool was used, in our area and beyond. In this way, this initiative could be an example for others to effectively use this or similar waste.

Keywords: *hardboard, wool, sustainability, recycling*

INVESTIGATION OF THE DEPENDENCE OF THE CUTTING POWER AND SURFACE ROUGHNESS ON THE PROCESSING MODE

Damjan Stanojevic

*Academy of Technical-Educational Vocational Studise,
Department of Vranje, Serbia
e-mail: damjan.stanojevic@akademijan.is.edu.rs*

ABSTRACT

Processing quality is considered one of the significant limiting parameters in maximizing the performance of woodworking machines. Regardless of the type of processing and its perfection, it is not possible to create a detail so that it "ideally" corresponds to the dimensions marked on the corresponding drawing. Newly created surfaces when cutting wood are never perfectly smooth, whether they are flat or curved.

The importance of the quality of the cut surface for practice is extremely high. It is not only about the aesthetic appearance of the surface obtained by cutting, but even more the consequences that a rough or wavy cut has on the value of the product. First of all, a rough or wavy cut results in a greater loss during planing, because a thicker layer must be removed in order to achieve a smooth surface. This means that post-processing creates more waste, and thus costs increase. The cleanliness of the cut depends on many factors. They are on the one hand related to the blade and its work in wood, and on the other hand to the type of blade and the machine that drives it. Knowledge of these factors indicates what should be paid attention to in wood processing when using various blades and machines, in order to achieve the highest possible cleanliness of the cut, less waste and thereby increase the value of the manufactured goods, and at the same time reduce production costs

In practice, the most important thing is to achieve a result, and it is also very important that the entire technological process of wood processing is done with the lowest possible costs. A large part of these costs is the consumption of power for cutting. There are many influencing factors on which power consumption depends. These are: the material being processed, the material from which the tool is made, the geometry of the tool, the speed of the main movement, the feed rate, etc.

In order to conduct a preliminary experimental investigation of the movement of cutting power and roughness of the cut surface as dependent variables depending on the processing mode and the size of bluntness of the tool as independent variables, an experiment was carried out at the Faculty of Forestry in Belgrade. The experiment was

supposed to provide answers to questions concerning the choice of processing modes that have a different impact on the quality of the cut surface as well as on the consumption of cutting power.

Keywords: *Cutting power, cut surface quality, processing mode, circular saw*

**INFLUENCE OF TECHNOLOGICAL DEVELOPMENT ON KITCHEN
DESIGN IN THE PERIOD FROM 2012 TO 2022 IN THE REPUBLIC OF
NORTH MACEDONIA**

Dijana Zafirovska

*Ss. Cyril and Methodius University in Skopje, North Macedonia,
Faculty of Design and Technologies of Furniture and Interior-Skopje,
PhD Student , e-mail: zafirovskad@yahoo.com*

ABSTRACT

The project of the kitchen space is subject to modification and influences that in the period from 2012 to 2022 are recognizable in parallel with the progressive evolution in modern technologies for the production of kitchen furniture elements. Technology is in constant development and has its own influence on kitchen design. The relationship between design and technology has been and will remain closely related to cultural phenomena and conditions. Analyzing the development process, the relationship in recent years, it can be concluded that it was influenced by new discoveries. The research will examine the reasons why and when standards are deviated from. Finally, how much it affects the quality of the interior and the organization of the kitchen.

The purpose of the research presented in this paper is to show the relationship between kitchen design and technology. Also the role of technology in efficiency is the functionality of kitchens. Technological advances do not make the tasks that were to be performed in the kitchen easier, but the kitchen is evolving into a multifunctional space that is as important as the rest of the housing space in terms of aesthetics. The intensive development of electrical equipment for the kitchen area opens up new perspectives in the project. Existence of issues such as lack of space and visual quality, in addition to the requirements of careful planning lead to the consideration of a solution such as technology.

The development of technology increases the possibilities of knowledge, but the logic that regulates the development risks dragging man under the dominance of mechanical automatisms and setting him in an opposing position with nature. Through an analysis of the development of technology, this paper as its ultimate goal presents the influences of technological development on the design of kitchens in North Macedonia in the period from 2012 to 2022.

Keywords: *technology, functionality, kitchen, development, organisation*

**ANALYSIS OF MATERIALS AND THEIR INFLUENCES ON KITCHEN
DESIGN IN THE PERIOD FROM 2012 TO 2022 IN THE REPUBLIC OF
NORTH MACEDONIA**

Dijana Zafirovska

*Ss. Cyril and Methodius University in Skopje, North Macedonia,
Faculty of Design and Technologies of Furniture and Interior-Skopje,
PhD Student , e-mail: zafirovskad@yahoo.com*

ABSTRACT

The aim of this research is to present the materials used in the design of kitchens. An analysis of the new materials for making kitchens will also be carried out. The kitchen project relies heavily on modern materials and they directly determine the project.

Through the analysis of new material trends, this paper processes a problem that is current and significant in the projecting and designing of the kitchen space. As its ultimate goal, it presents the influence of materials on kitchen design in the period from 2012 to 2022 in North Macedonia. Several types of materials such as veneer boards, MDF boards and laminates have been analyzed to study the influences.

Keywords: *analysis, materials, veneer boards, MDF boards, laminates*

INFLUENCE OF THE MATERIAL FROM WHICH THE PROFILE IS MADE ON THE FINAL QUALITY OF THE WINDOW

Elena Jevtoska¹, Gjorgji Gruevski¹

¹*Ss. Cyril and Methodius University in Skopje, Macedonia,
Faculty of Design and Technologies of Furniture and Interior-Skopje
e-mail: jevtoska@fdtme.ukim.edu.mk; gruevski@fdtme.ukim.edu.mk*

ABSTRACT

The window as a product used in construction aims to provide natural light and the possibility for ventilation in the building where it is placed but at the same time to protect the room from external influences such as wind and rain and to prevent uncontrolled cooling or heating of the building in which it is built-in. Given the purpose, a quality window is one that protects against air penetration, water penetration and provide wind resistance. The window is a complex product that is composed of different parts that can be made of different materials. As part of this research, windows constructed from profiles made of different materials (wood, PVC, aluminum) with approximately the same dimensions of the profiles will be tested. The same type of glass package will be built in every window. The goal is to prove whether the material which is used for making the window profile has an impact on the final quality of the window. To carry out the research, thirty windows will be tested of which ten are made of wooden profile, ten of aluminum profile and ten of PVC profile in accordance with European norms EN 1026: 2016 (test method for air permeability), EN 1027: 2016 (water permeability test method), EN 12211: 2016 (wind resistance test method).

Keywords: *construction carpentry, window, air permeability, water permeability, wind resistance, PVC profiles*

SOCIAL ENTREPRENEURSHIP AND SOCIAL DESIGN: CATALYZING INCLUSIVE INNOVATION FOR PEOPLE WITH DISABILITIES

Maria Kitchoukova¹, Emil Kitchoukov¹

*¹University of Forestry, Bulgaria,
e-mail:mkitchoukova@yahoo.com;ekitchoukov@yahoo.com*

ABSTRACT

This study explores the interplay between social design and social entrepreneurship, with a specific focus on promoting inclusion and empowerment for people with disabilities. Social design, with its emphasis on human-centered, empathetic, and participatory methodologies, has the potential to drive social entrepreneurship initiatives that adequately cater to the needs and aspirations of individuals with disabilities.

In this context, the paper delves into the principles and methodologies of social design and their implications for social entrepreneurship, examining how such approaches can foster inclusive innovation. The role of co-creation with people with disabilities, a fundamental principle of social design, is underscored as a vital strategy for developing entrepreneurial solutions that truly address the lived experiences and challenges of this population.

These case studies illustrate how social design can guide the development of products, services, or systems that are not only accessible and functional, but also empower individuals with disabilities to lead fulfilling and independent lives.

Keywords: *social design, social entrepreneurship, people with disabilities*

INNOVATION AND INNOVATIVENESS IN WOOD INDUSTRY

Mira Stankevikj Shumanska

*Ss. Cyril and Methodius University in Skopje, R. of North Macedonia,
Faculty of design and technologies of furniture and interior-Skopje
e-mail: stankevik@fdtme.ukim.edu.mk*

ABSTRACT

In today's modern business world, development of innovations and innovation activities is considered as a key driver of business success of an individual entity, specific industry sector, as well as the overall economy of a country. However, industries of low and/or medium-low technology, where wood industry belongs, are extremely important and they represent by far the largest part of the manufacturing sector in each country. They show an excellent stability and employ a high share of the population. Wood industry, especially furniture industry, is a successful export-oriented European industry. Innovative companies and innovation as a result of innovativeness can be attached to a number of internal and external company factors. The connections between concepts of innovation and innovativeness of certain internal and external company factors have/could have an impact on company innovativeness and innovation development.

Keywords: *wood industry, innovation, innovativeness*

**THE PHOTOVOLTAIC SYSTEM AS A PART OF ENERGY PRODUCTION
IN THE WOOD INDUSTRY IN SERBIA**

Mladen Furtula

*University of Belgrade-Faculty of Forestry
e-mail:mladen.furtula@sfb.bg.ac.rs*

ABSTRACT

The wood industry is a type of industry that can use its wood residues for energy production and thus be a part of energy producers from renewable sources. Another type of potential green energy production comes from the often large roofs of its buildings that can be covered with solar panels, thus expanding their energy production capacity and thus reduce the need for electricity production from fossil fuels. The paper shows the photovoltaic system's integration into energy production and its impact on the environment. Also, it will be shown how producers can connect to the electric system.

Keywords: *photovoltaic, energy production, green energy*

METROLOGY OF THE GEOMETRIC CHARACTERISTICS OF MORTISE AND TENON JOINTS THROUGH GEOMETRIC PRODUCT SPECIFICATION (GPS) STANDARDS

Nikola Mihajlovski¹, Gjorgji Gruevski¹

¹*Ss. Cyril and Methodius University in Skopje, Macedonia,
Faculty of Design and Technologies of Furniture and Interior-Skopje,
e-mail: mihajlovski@fdtme.ukim.edu.mk; gruevski@fdtme.ukim.edu.mk*

ABSTRACT

The application of tolerances and fits and the accuracy control of processing are necessary requirements of any modern furniture production. The tolerances and fit preferences of the functional surfaces in the joint have a considerable impact on the quality and durability of a wood chair's construction. The mutual interaction of the contact surfaces of the mortise and tenon joints is complex. The geometry of the joint affects the tribology of these surfaces. The optimal shape of mortise and tenon joints is also represented by their geometric features.

The Geometric Product Specification System (GPS) is a set of guidelines, concepts, and symbols that establish the geometry of a part's allowable tolerances in order to guarantee its functionality.

This review paper presents an investigation of the possibilities for metrology of the geometrical characteristics of mortise and tenon joints and their expression and representation through Geometrical Product Specification (GPS) standards. For this purpose, a metrology of the most commonly used joint in wood chair construction is presented. The following types of tolerances are presented: dimension tolerances (length, width and thickness); form tolerances (straightness and flatness); orientation tolerances (parallelism and perpendicularity); location tolerances (position and coaxiality).

Metrology and presentation of the geometric characteristics of mortise and tenon joints through GPS standards is a useful method that satisfies functional requirements and quality control during processing.

Keywords: *geometric caraceristics, mortise and tenon joints, tolerances, metrology*

INFLUENCE OF VACUUM DRYING ON COLOUR CHANGES AND DRYING QUALITY OF OAK AND LINDEN TIMBER

Zdravko Popovi ¹, Igor Lukovi ², Goran Mili ¹, Ranko Popadi ¹

¹University of Belgrade – Faculty of Forestry, Department of Wood Science and Technology, Belgrade, Republic of Serbia

²Zomont d.o.o. Beograd, Republic of Serbia

e-mail: zdravko.popovic@sfb.bg.ac.rs; igor.lukovic95@gmail.com;

ranko.popadic@sfb.bg.ac.rs; goran.milic@sfb.bg.ac.rs

ABSTRACT

This study examined the quality of oak and linden timber after conductive (contact) vacuum drying. Initial and final moisture content (MC), MC gradient, casehardening and colour (both before and after drying) were determined for two test runs of oak timber (thickness 50 and 25 mm) and one test run of linden timber (40 mm thick). The drying rate for oak boards ranged from 2.3% to 2.8% per day, strongly influenced by the initial MC and thickness, while for linden wood this rate was nearly double – 4.65% per day. The final MCs achieved were 2% to even 5% lower than the targeted values, which confirmed the occasional issues of overdrying in conductive vacuum kilns. The MC gradient and casehardening were minimal, while the colour of the dried timber appeared slightly darker for oak and even brighter for linden compared to their pre-drying state. These findings confirm the effectiveness of vacuum kilns with heated platens in efficiently drying wood species with naturally bright colours.

Keywords: wood drying, vacuum kiln, moisture content, casehardening, colour

THE INFLUENCE OF PARTICLEBOARD SQUARENESS ON THE EDGE BONDING QUALITY

Igor Džini¹, Tanja Palija¹

University of Belgrade,

*¹Faculty of Forestry, Department of Wood Science and Technology
e-mail: igor.dzincic@sfb.bg.ac.rs; tanja.palija@sfb.bg.ac.rs*

ABSTRACT

This paper shows the influence of the squareness of wood-based panels on the quality of edge bonding. Edge bonding of wood-based panels can be done by applying different types of adhesives and using different types of edge materials. The number of factors that affect the quality of bonding is large. Analysis of wood-based panels squareness after processing by pre-cutters, as well as the position of the roller for applying glue to the panels, was analyzed. The static analysis showed that there is a significant influence of the measured parameters on the strength of the edge bonding quality. Variation of the observed factor, leads to a change in the quality of the bonding quality. The highest strength of the glued joint was shown by the samples with the smallest angular deviation of the edge to the wider side of the panel. The minimum strength that the edge bonding should require are not defined by the standard.

Keywords: *wood-based panels, edge bonding, squareness, internal bond*

ANALYSIS OF HEAT AND STEAM CONSUMPTION DURING ARTIFICIAL CONVECTIVE DRYING OF OAK SAWN TIMBER OF DIFFERENT THICKNESS

Goran Zlateski¹, Ana Marija Stamenkoska¹, Zoran Trposki¹, Vladimir Koljozov¹

¹*Ss. Cyril and Methodius University in Skopje, North Macedonia,
Faculty of design and technologies of furniture and interior-Skopje
e-mail: zlateski@fdtme.ukim.edu.mk, stamenkoska@gmail.com,
trposki@fdtme.ukim.edu.mk, koljozov@fdtme.ukim.edu.mk*

ABSTRACT

In the paper, the consumption of heat and steam of oak sawn timber with a thickness of 25,0 and 50,0 (mm) are analyzed under conditions of classic convective drying. The drying mode is compiled on the basis of data on the temperature of the drying agent (air), the relative humidity of the air and the speed of air movement in accordance with the current value of moisture in the wood.

The heat consumption is analyzed in all stages of the drying cycle such as heating the wood, active drying of the wood, equalization of the average moisture in the wood and conditioning, i.e. equalization of the moisture in the cross-section within ± 2.0 (%). The moisture content of sawn timber at the beginning of drying is about 55,0 (%) and at the end of drying is 10,0 (%). The sawn timber are intended for the production of solid wood panels.

Keywords: *oak, sawn timber, artificial drying, heat consumption, steam consumption*

EXPERIMENTAL RESEARCH ON BENDING STRENGTH FOR ANGLE AND MIDDLE CONNECTIONS MADE OF BEECH WOOD IN CONSTRUCTIONS FROM UPHOLSTERED FURNITURE

Naumche Ugrinovski¹, Gjorgji Gruovski¹, Nacko Simakoski¹

¹ Ss. Cyril and Methodius University in Skopje, R. of North Macedonia,
Faculty of design and technologies of furniture and interior-Skopje
e-mail: nugrinovski@yahoo.com; gruveski@fdtme.ukim.edu.mk,
simakoski@fdtme.ukim.edu.mk

ABSTRACT

Upholstered furniture products, especially seating sets, are one of the most frequently and frequently used products by people. They are in direct interaction with the human body, and from that comes a great responsibility that is required of them, both from a hygienic and health, as well as from a safety point of view. It is necessary to pay great attention when constructing the structure. The furniture it should be strong and durable during use. The tests of the strength characteristics are performed according to recognized methods of Kyuchukov (LTU-Sofia) and international standards BDS 9165/7, BDS 16712/87, BDS-13087/89. According to these Methods and Standards, tests were carried out on test bodies made of beech wood and using structural connections, only by gluing the elements, then by gluing and with connections for the constructive assembly of the elements in the construction of upholstered seating furniture. Beech wood material from the Belasica mountain area with its well-known physical and mechanical properties examined by other authors was selected. From the tests on the strength characteristics for the specified fixed angular structural compositions, results have been obtained that are comparable to the tests of the group of authors from other countries on the same issue, which are in certain equivalences.

In the following text, reference will be directed to researching the strengths of some frequently used end corner connections in frame constructions made of massive beech wood in upholstered sets. This will cover first of all the constructive requirements in terms of rationality, strength and reliability in use, but also some of the other requirements, especially the technological and technological-economic ones, due to the natural connection with them.

Keywords: Upholstered furniture, strong, strength characteristics, beech wood, bending strengths, gluing, fixed, angle, construction