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Vesna Žegarac Leskovar[1], Miroslav Premrov[1], Manja Kitek Kuzman[2]

Energy-Efficient Renovation Principles for Prefabricated Timber-Frame Residential Buildings

Energetski učinkovita načela obnove montažnih stambenih zgrada s drvenim okvirom

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ABSTRACT • *The timber construction along with the use of suitable and correctly oriented glazing surfaces, whose thermal and strength properties have been considerably improved over the years, represents a great potential in residential and public building construction. However, necessary renovations of the older structures, which present quite a large share of residential fund, should not be overlooked. Moreover, those structures should be adequately energy renovated by the year 2020. Therefore, the key contribution of this paper is the presentation of the available renovation principles, and namely a combination of the improvement of buildings envelope thermal properties, usage of a proper type of installation and share of glazing surfaces in the south-oriented façade, according to affordable investment input. In order to achieve minimal heating and cooling annual energy demand, in the current parametric study, different options were carried out with double-layer and triple-pane glazing, installed in three different types of wall elements, demonstrating the value of optimal glazing surface.*

Keywords: *timber building, glazing, energy efficiency, renovation*

SAŽETAK • *Drvena konstrukcija, uz uporabu odgovarajućih i pravilno orijentiranih staklenih površina čija su toplinska svojstva i čvrstoća tijekom godina znatno poboljšani, velik su potencijal u gradnji stambenih i javnih zgrada. Pritom ne smije biti zanemarena ni obnova starijih objekata, koji čine prilično velik udio u stambenom fondu. Usto ti bi objekti do 2020. godine trebali biti odgovarajuće energetski obnovljeni. Dakle, važan doprinos ovog članka jest predstavljanje raspoloživih načela obnove kao što su kombinacija poboljšanih toplinskih svojstava fasade zgrade, primjena odgovarajućeg tipa instalacija i udjela staklenih površina na južnoj fasadi, ovisno o mogućemu investicijskom ulaganju. Kako bi se postigla minimalna godišnju potreba za grijanjem i hlađenjem, u parametarskoj studiji izvedene su različite mogućnosti s dvoslojnim i troslojnim zastakljenjem, ugrađenima u tri različita tipa zidnih elemenata, čime se demonstrira vrijednost optimalnih staklenih površina.*

Ključne riječi: *drvena gradnja, zastakljivanje, energetska učinkovitost, obnova*

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1 INTRODUCTION
1. UVOD

Timber as a material for load bearing construction represents a future challenge for residential and public buildings. Being a natural raw material, timber represents one of the best choices for energy efficient construction since it is also a material with good thermal properties, compared to other construction materials. In addition, it plays an important role in the reduction of the CO_2 emissions (Natterer, 2009), it has good mechanical properties (Vratuša *et al*., 2011) and ensures a comfortable indoor living climate. Timber construction has better thermal properties than conventional brick or concrete construction methods, even with smaller wall thickness. Considering the growing importance of energy-efficient building methods, timber construction will play an increasingly important role in the future.

Residential buildings represent the biggest share (47 %) of the existing buildings is Slovenia. More than half of them are made of brick (56 %), 16 % of concrete and mixed construction, and the rest made of materials including timber are represented to a smaller extent (Kitek Kuzman *et al*., 2010). Focusing to the Slovenian timber construction, current rise has been noticed, even though the percentage of new timber buildings in Slovenia is still small regarding the entire new construction, especially in the public buildings sector. In 2010 (SORS), the percentage of newly built pre-fabricated houses, mostly one or two-family, exceeded 15 % and the percentage is expected to increase to 20-30 % over the next five years.

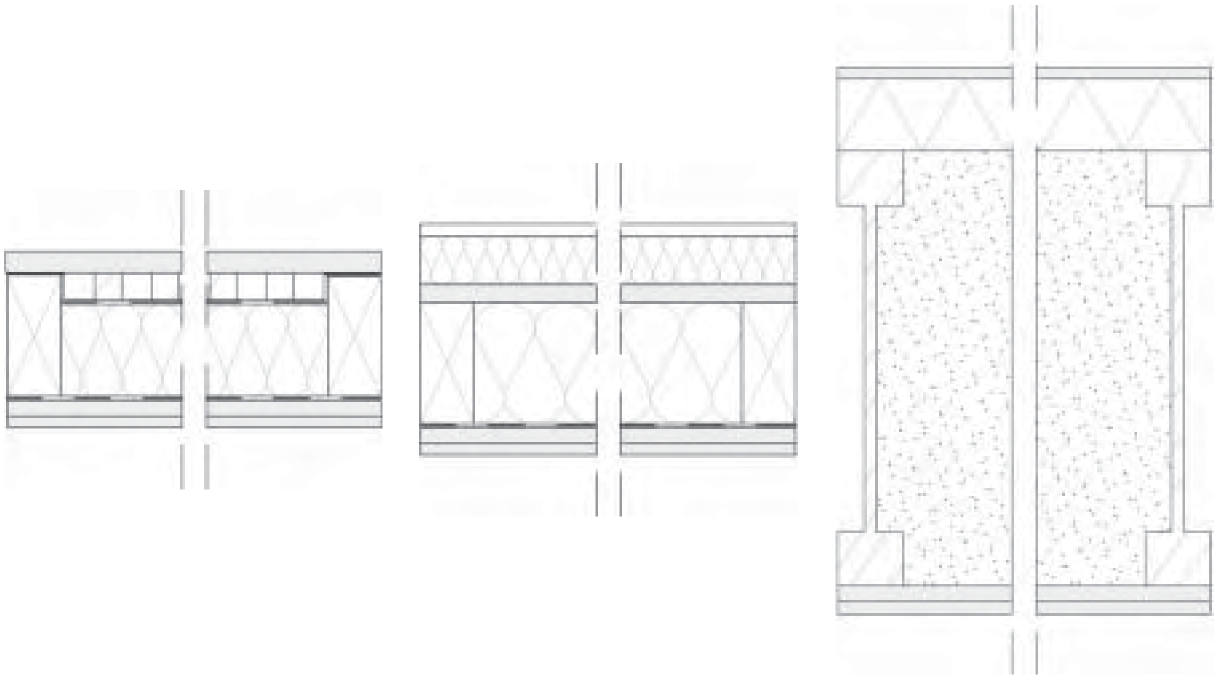
The dominating methods of timber construction in Slovenia include a timber-frame construction, balloon and massive construction. Currently, most Slovenian companies offer houses with timber-frame construction. Timber panel construction has had its own production in Slovenia and Croatia for more than 35 years. The beginnings of pre-fabricated construction started after the second world war, when the barracks were put up for the people who had been left without shelter and those who had migrated from the countryside. Over the past thirty years, timber in Europe construction has undergone major changes. The most important changes introduced are the following (Premrov, 2008): transition from on-site construction to factory prefabrication, transition from elementary measures to modular building and development from a single-panel to a macro-panel wall prefabricated panel system. All of these greatly improve the speed of building.

In timber-frame buildings, the basic vertical load bearing elements are panel walls consisting of load bearing timber frames and sheathing boards. Depending on wall dimensions, one can distinguish between single-panel and macro-panel wall systems. The single-panel was based on the individual smaller elements in dimensions of 1.30 m (1.25 m) x 2.5 m to 2.65 m (Figure 1a). The height of the wall elements met the height of the floor and the length of the ceiling elements the span of the bridged field. The macro-panel system has been developed from the single-panel system in the last two decades and represents an important milestone in panel timber frame building. The aim of the system is to provide whole wall assemblies, including windows and doors, which are totally constructed in a horizontal plane in a factory from where they are transported to the building-site. Prefabricated timber-frame walls, as the main vertical bearing capacity elements, of typical dimensions with a width of 1250 mm and a height of 2500–2600 mm, are composed of a timber frame and sheets of board-material fixed by mechanical fasteners, usually staples, to one or both sides of the timber frame (Figure 1c).

Table 1 Composition of analysed macro-panel (TF 3) and single-panel (TFCL 2, 3) timber-frame wall elements
Tablica 1. Kompozicija analiziranih makropanelnih (TF 3) i jednopanelnih (TFCL 2, 3) zidnih elemenata s drvenim okvirom

TF 3		**TFCL 2**		**TFCL 3 – renovation**	
material / *materijal*	*d*, mm	material / *materijal*	*d*, mm	material / *materijal*	*d*, mm
rough coating *hrapava obloga*	10	wooden planks *drvene oplate*	22	rough coating *hrapava obloga*	10
wood fibreboard *ploče vlaknatice*	60	/	/	mineral wool *mineralna vuna*	40
/	/	TSS*** / open air gaps / bitumen	0.5	gypsum fibreboard *gipsane vlaknatice*	15
cellulose fibre / TF* *celulozna vlakna*	360	TSS*** / open air gaps / TF*	20	mineral wool / TF* *mineralna vuna*	100
		bitumen sheet cardboard / TF* TF*MW	0.5		
		mineral wool / TF* *mineralna vuna*	80		
OSB**	15	aluminium foil *aluminijska folija*		aluminium foil *aluminijska folija*	
gypsum plasterboard *gipsana fasadna ploča*	12.5	particleboard *ploča iverica*	13	particleboard *ploča iverica*	13
		gypsum plasterboard *gipsana fasadna ploča*	10	gypsum plasterboard *gipsana fasadna ploča*	10
total thickness, mm *ukupna debljina, mm*	457.5	total thickness, mm *ukupna debljina, mm*	146	total thickness, mm *ukupna debljina, mm*	188
U_{wall}–value, W/m²K	0.102	U_{wall}–value, W/m²K	0.48	U_{wall}–value, W/m²K	0.30

*timber frame / **drveni okvir*, **oriented strand board / ***ploča s orijentiranim iverjem*, ***timber sub-structure / *** *drvene podstrukture*



a) b) c)

Figure 1 a) single-panel system (TFCL2); b) renovated single-panel system (TFCL 3), c) timber-frame wall element with I-studs (TF 3)
Slika 1. a) jednopanelni sustav (TFCL2); b) obnovljeni jednopanelni sustav (TFCL 3), c) zidni element s drvenim okvirom i I-stupovima (TF 3)

Between the timber studs and girders, a thermal insulation material is inserted whose thickness depends on the type of external wall. Composition of all analysed wall elements is presented in detail in Table 1.

The first single-panel systems in Slovenia were used by Marles and Jelovica. In Slovenia and Croatia there are a few settlements built in the early 70s. For an illustration, Table 2 gives figures of the houses produced by the Company Marles Houses in the period from 1964 to 1987.

Those first pre-fabricated houses had very good thermal properties of external envelope. Thermal transmittance of the best panel types was always much lower than provided by regulations; for example thermal insulation improved by nearly three times from 1963 to 1972, and after 1992 it was almost four times better than specified by the current national regulations (Figure 2). Due to the reduction of energy losses in the newly built residential structures, the first measure introduced by producers was a gradual reduction of thermal transmittance of external wall elements, resulting in the increase of thickness of the timber-frame wall elements, thus enabling the installation of thicker thermal insulation. Detailed composition of construction of the older single-panel external wall elements, as well as the newer macro-panel system, are explicitly presented in Table 1, with the additional graphic presentation in Figure 1. Figure 2 only shows data until the year 1992, when

Table 2 Number of Marles' pre-fabricated houses from 1964 to 1987 (archive company Marles hiše Maribor).
Tablica 2. Broj Marlesovih montažnih kuća od 1964. do 1987. (arhiva tvrtke Marles hiše, Maribor)

MARLES pre-fabricated houses (purpose) / *MARLES montažne kuće (namjena)*	**Produced number** *Broj proizvedenih kuća*
residential settlements, terraced houses / *stambena naselja, terasaste kuće*	590
schools / *škole*	90
kindergartens / *dječji vrtići*	360
health centres / *domovi zdravlja*	40
individual structures *individualni objekti* (1964-1999)	10 000

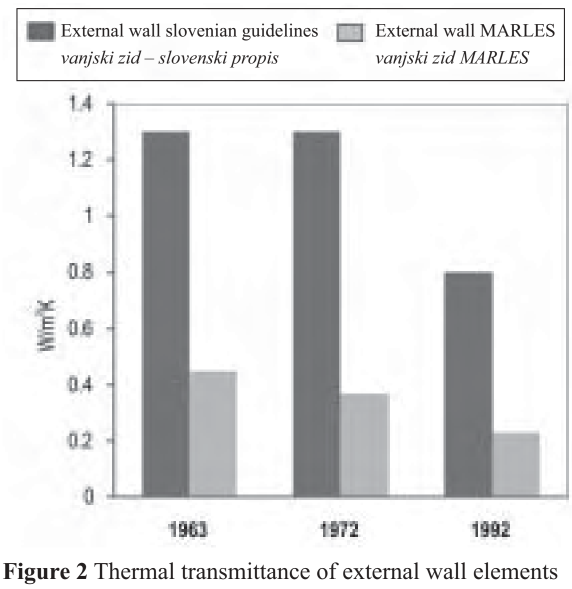


Figure 2 Thermal transmittance of external wall elements - *U*-value comparison of the Marles' wall with the Slovene regulations in the period 1963 to 1992
Slika 2. Toplinski prijenos vanjskih zidnih elemenata – usporedba *U*-vrijednosti Marlesova zida sa slovenskim propisima u razdoblju od 1963. do 1992.

the external wall elements met, for the first time, the requirements of the regulations currently applicable in Slovenia regarding energy efficient construction, so that the thermal transmittance of exterior was, for the first time, lower than the prescribed limit value of 0.28 W/m²K, i.e. it has nearly reached the value for light constructions, which is 0.20 W/m²K (PURES, 2010). Therefore, all prefabricated timber framed structures set up before the year 1992 are considered as a fund needing energy efficient renovation by the year 2020. The latter refers to the wide-ranging package on climate change adopted by the European Union, the overall 20-20-20 targets, which are binding for buildings, too. Therefore, the energy performance of the existing buildings has to be improved through a complex process of energy efficient renovation, and likewise a sustainable new construction of energy-efficient buildings with the use of renewables has to be performed.

2 ENERGY-EFFICIENT BUILDINGS
2. ENERGETSKI UČINKOVITE ZGRADE

Researching energy efficiency of buildings is not a matter of the last decade only, since the first intensive studies related to energy and buildings were already carried out in the seventies and eighties of the last century. Many studies focusing on the research of specific parameters influencing energy performance of buildings, such as Johnson *et al.* (1984) and Steadman *et al.* (1987) have been performed since then. Previous research findings indicate that the process of defining the optimal model of a building is very complex. The most important parameters influencing energy-performance of buildings are listed below:

- location of the building and climate data for the specific location,
- orientation of the building,
- properties of installed materials, such as timber, glass, insulation, boards, etc.,
- building design (shape factor, length-to-width ratio, window-to-wall area ratio, building envelope properties, windows properties),
- selection of active technical systems.

According to the Slovene legislative framework, particularly the Energy Act, the system of energy performance certification is defined in *Rules on the methodology of construction and issuance of building energy certificates (2009)*. On the basis of these rules, the classification of energy-efficient houses was carried out, as listed in Table 3.

Table 3 clearly shows that energy efficient structures can be constructed only by an adequate combination of external envelope efficient insulation and high quality glazing installation. Respecting climate change conditions and the subsequent European directions related to energy performance of buildings, the building industry must construct a nearly zero energy house by 2020. Searching for the optimal model of an energy-efficient house has, therefore, become an issue of major importance. Similar concept of optimal solution will consequently have to be introduced into the field of renovation of numerous older buildings, which are far from achieving standards of energy efficient buildings. Therefore, our analysis is directed into the field of prefabricated timber-frame construction, which will try to find an optimal renovation solution as combination of additional layers of insulation on the external wall elements and double-layer or triple-pane quality glazing.

Table 3 Classification of energy-efficient houses on the basis of "Rules on the methodology of construction and issuance of building energy certificates"
Tablica 3. Klasifikacija energetski učinkovitih kuća na temelju *Pravilnika o metodologiji gradnje i izdavanja energetskih certifikata za zgrade*.

Degree / Classification in accordance with the rules *Klasifikacija u skladu s pravilima*	**Generally used classification in practice** *Općenito primjenjivana klasifikacija u praksi*	**Q_h*** (kWh/m²a)	**Variation of execution** / *Varijanta izvedbe* (according to Praznik and Kovič, 2010)
Class C / *klasa C*	minimal requirements for low-energy house *minimalni zahtjevi za nisko-energetsku kuću*	35 – 50 (60)	classical prefabricated construction, conventional heating system, contemporary windows (doors), no central ventilation system / *klasična konstrukcija, konvencionalni sustav grijanja, suvremeni prozori, bez središnjega ventilacijskog sustava*
Class B2 / *klasa B2*	low-energy house *niskoenergetska kuća*	25 – 35	thermally improved building envelope *toplinski poboljšana fasada zgrade*
Class B1 / *klasa B1*	better low-energy house *bolja niskoenergetska kuća*	15 – 25	thermally improved building envelope + HRV** + HP*** / *toplinski poboljšana fasada zgrade + HRV** + HP****
Class A2 / *klasa A2*	passive house *pasivna kuća*	10 – 15	additionally thermally improved building envelope + HRV + HP / *dodatno toplinski poboljšana fasada zgrade + HRV + HP*
Class A1 / *klasa A1*	1-litre house	≤ 10	additionally thermally improved building envelope + HRV +HP + improved U-value of windows (doors) / *dodatno toplinski poboljšana fasada zgrade + HRV + HP +poboljšana U-vrijednost prozora (vrata)*

* specific annual heating demand / *specifična godišnja potreba*, **heat recovery ventilation / *povrat energije*, ***heat pump / *toplinska pumpa*

3 NUMERICAL STUDY
3. NUMERIČKA STUDIJA

This chapter presents a numerical case study of a two-storey house and its parametric analysis of the impact of the glazing-to-wall area ratio on energy demand. The influence of south oriented glazing area size on heating and cooling energy demand is analysed in the case-study of a single-family house, carried out with three different types of external wall elements:

a) a new macro-panel timber-frame wall element (TF 3), which satisfies the requirements of a passive house design, of a total thickness of 456.5 mm and U_{wall} value of U = 0.102 W/m²K (Table 1, Figure 1c),
b) an old classical single-panel timber-frame wall element (TFCL 2) of a total thickness of 146 mm and U_{wall} value of U = 0.480 W/m²K (Table 1, Figure 1a).
c) a renewed timber-frame single-panel wall element (TFCL 3) of a total thickness of 195 mm and a U_{wall} value of 0.30 W/m²K, which is developed from the TFCL 2 old system by inserting an additional insulation in the external side of timber frame (Table 1, Figure 1b) – case of renovation.

3.1 Simulation model
3.1. Simulacijski model

Description of the base case study model

The external horizontal dimensions are 11.66 m x 8.54 m for the ground floor and 11.66 m x 9.79 m for the upper floor (Figure 3). The total heated floor area is 168.40 m² and the total heated volume is 437.80 m³.

Climate and orientation

The house is located in Ljubljana with its longer side, the large glazed area, facing south. The city of Ljubljana is located at an altitude of 298 metres, latitude of 46°03' and longitude of 14°31' east. According to data from *http://www.geodetska-uprava.si/DHTML_HMZ/wm_ppp.htm* the considered average annual external temperature is 9.8 °C**.** The average duration of solar radiation is 1712 hours annually.

Construction

Exterior walls are constructed in three different variations, as presented in Table 1. For all analysed wall elements, the timber characteristics are of the same class - C22 according to *EN 338*. The *U*-values of other exterior construction elements are in all cases 0.135 W/m²K for the floor slab, 0.135 W/m²K for the flat roof and 0.130 W/m²K for the south-oriented overhang construction above the ground floor area.

Glazing

Two types of glazing were separately considered in the analysis:

a) a window glazing (Unitop 0.51 – 52 UNIGLAS) with three layers of glass, two low-emissive coatings and Krypton in the cavities for a normal configuration of 4E-12-4-12-E4. The glazing configuration with a *g*-value of 52 % and U_g = 0.51 W/m²K assures a high level of heat insulation and light transmission, Gustavsen *et al.* (2007). The window frame *U*-value is U_f = 0.73 W/m²K, while the frame width is 0.114 m.
b) a window glazing with two layers of glass, one low-emissive coating and Argon in the cavity for a normal configuration of 4-16-E4, with a *g*-value of 60 % and U_g = 1.2 W/m²K. The window frame *U*-value is U_f = 1.11 W/m²K, while the frame width is 0.116 m.

The glazing-to-wall area ratio (AGAW) of the base case in the south-oriented façade is 27.6 %, while the AGAW values of the rest of the cardinal directions are 8.9 % in the north-oriented, 10.5 % in the east-oriented and 8.5 % in the west-oriented façades.

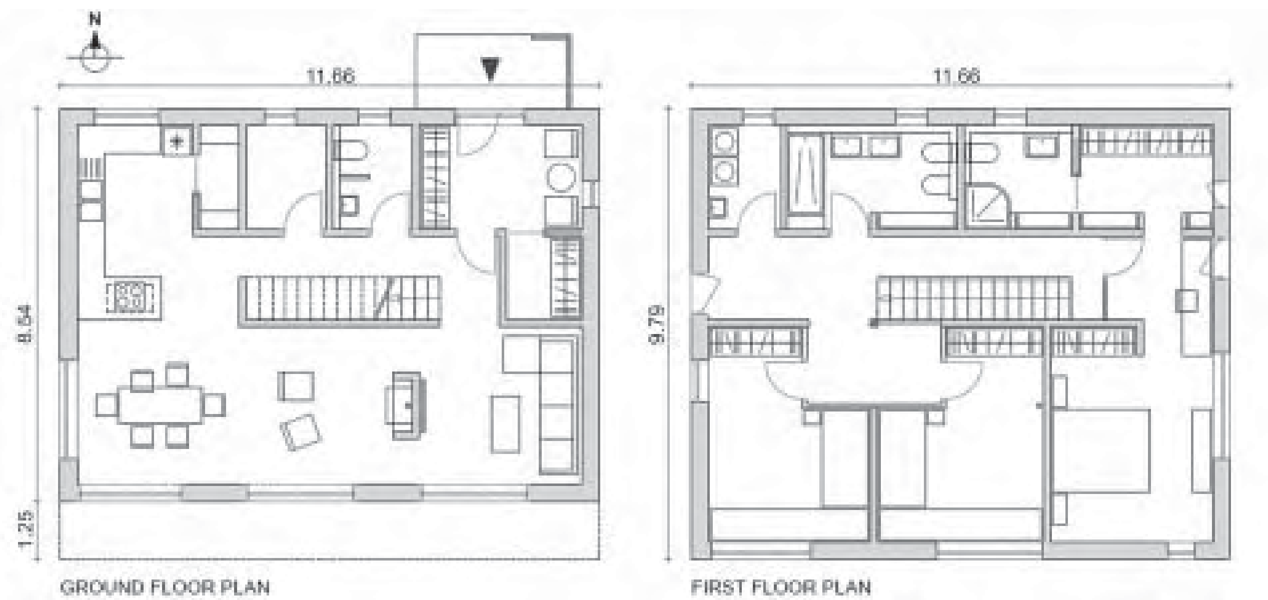


Figure 3 Floor plans of the base-case study model
Slika 3. Tlocrt osnovnog modela proučavanja

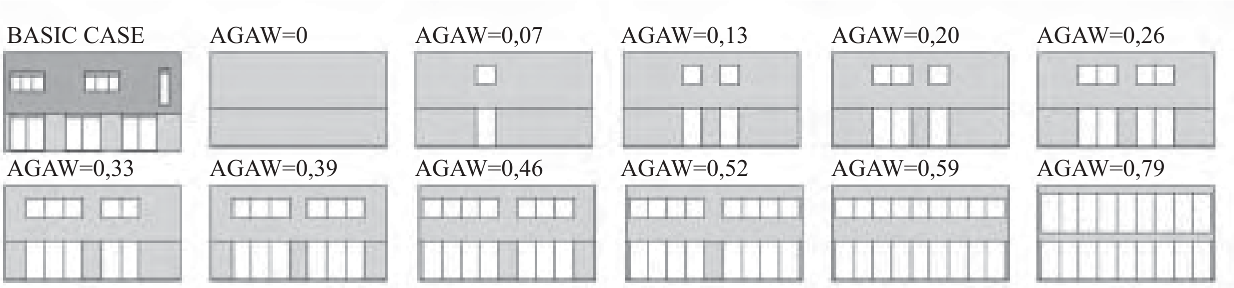


Figure 4 South-oriented façade of the base-case model with schemes of AGAW modification
Slika 4. Južna fasada osnovnog modela sa shemama AGAW modifikacije

Shading

The house is constructed with a south-oriented extended overhang above the ground floor, which blocks the direct solar radiation from entering the ground floor windows to the south during the summer, while it lets it enter in winter when the angle of incidence of the sun is lower. The rest of the windows on the upper floor and those of the east- and west-oriented walls are shaded with external shading devices.

Internal gains and HVAC

The house is equipped with a central heat recovery unit. To prevent overheating in the summer period, night ventilation with cooling through manual window was planned. The interior temperatures were designed to a T_{min} of 20 °C and T_{max} of 25 °C. Domestic hot water generation (DHW) and an additional requirement for space heating are covered by a heat pump with a subsoil heat exchanger and, to a minimal extent (5 %), by electric heating.

Variable parameters

The influence of the glazing area size on energy demand was only studied in the south cardinal direction. It is known from our previous research (Žegarac, 2011; Žegarac and Premrov, 2011) that the influence of the size of incremental glazing area in other cardinal directions (N, W and E) on the total energy demand is negative, therefore only the south façade of the building is the point of our interest. Modifications of the glazing area size on the south façade were performed in the range of AGAW from 0 % to nearly 80 %. Modifications of the glazing area size were made step by step by adding window elements (frame + glazing) to the totally unglazed façade, as presented in Figure 4.

Description of software and calculation method

The *Passive House Planning Package 2007* was used to perform calculations of energy demand. The software, certified as a planning tool for passive houses, providing a surprisingly accurate description of the thermal building characteristics of passive houses, can also be used for low-energy house design. Practice has shown that the results achieved by PHPP software are very similar to the energy demand measured in operating buildings.

4 RESULTS AND DISCUSSION
4. REZULTATI I RASPRAVA

4.1 Results for macro-panel TF 3 system – new type of passive timber-frame building
4.1. Rezultati za makropanelni TF 3 sustav – nova vrsta pasivne građevine drvene konstrukcije

The results of annual energy demand for heating (Q_h), cooling (Q_k) and the sum (Q_h+Q_k) for the three (TG) and double-layer glazing (DG) as a function of the glazing area size (AGAW = $A_{gl.,S}$ /$A_{wall,S}$) for the south cardinal direction are listed in Table 4 and graphically presented in Figure 5.

The above data clearly show that the increase in the size of the glazing surfaces in the south façade has a relatively positive influence on the heating energy demand and shows almost linear behaviour in both cases

Table 4 Energy demand for TF 3 structural system using triple-layer (TG) and double-layer glazing (DG)
Tablica 4. Energetske potrebe za gradbeni sustav TF 3, uz troslojno (TG) i dvoslojno zastakljenje (DG)

TF 3 modification South	$A_{glass\,S}/A_{wall\,S}$	Q_h kWh/m²a		Q_k kWh/m²a		$Q_h + Q_k$ kWh/m²a	
		TG	DG	TG	DG	TG	DG
M1S	0.767	11.13	23.25	11.01	12.58	22.14	35.83
M2S	0.573	13.91	24.46	6.67	8.13	20.58	32.59
M3S	0.510	14.59	24.48	5.6	6.97	20.19	31.45
M4S	0.446	15.25	24.45	4.62	5.88	19.87	30.33
M5S (opt. for TG)	0.382	16.00	24.49	3.74	4.87	19.74	29.36
M6S	0.319	16.84	24.61	2.96	3.91	19.80	28.52
M7S	0.255	17.81	24.84	2.31	3.05	20.12	27.89
M8S	0.191	18.91	25.18	1.75	2.28	20.66	27.46
M9S	0.127	20.17	25.66	1.30	1.65	21.47	27.31
M10S (opt.for DG)	0.064	21.48	26.16	0.93	1.14	22.41	27.30
M11S	0.000	22.99	26.84	0.64	0.76	23.63	27.60

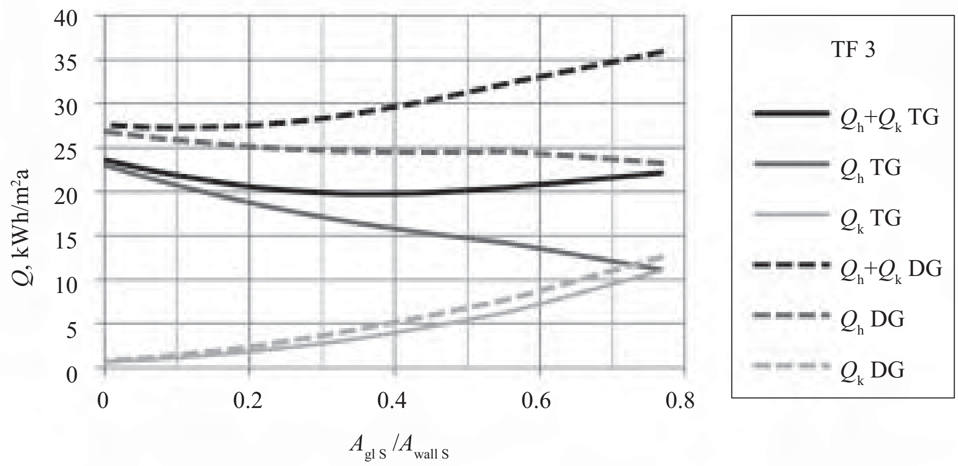


Figure 5 Annual energy demand in the passive TF 3 construction system as a function of AGAW for triple-layer (TG) and double-layer glazing (DG)
Slika 5. Godišnja energetska potreba u pasivnome gradbenom sustavu (TF 3) kao funkcija AGAW za troslojno (TG) i dvoslojno (DG) zastakljenje

of glazing. The function inclination, which physically represents the energy heating benefits, is essentially bigger in the case of the triple-layer glazing. On the other hand, the comparison between patterns of the cooling demand behaviour shows that the glazing type is not so important as heating.

The results for the sum of total energy demand show in both cases an interesting phenomenon related to the optimal point with the lowest Q_h+Q_k demand, which is in the TF 3 construction system by AGAW = 0.382 and results in the energy saving of 3.89 kWh/m^{2}a (or 16.46 %) according to the value by AGAW = 0 (Table 4). The values for the double-layer glazing are essentially different; the optimum point is at AGAW = 0.064 and produces an energy saving of 0.30 kWh/m^{2}a only (or 1.09 %), see Table 4.

The presented results generally match well with the results of the parametric study research on the effect of the glazing type and size on annual heating and cooling demand made by (Ford *et al*., 2007). The results carried out for the climate in Milan, which are similar to our case, show that there is practically no significant influence of the glazing type on the cooling demand, while there is a strong impact on the energy heating demand. The results of the Swedish study for the climate in Lund, carried out by Bullow-Hube (2001), also show almost negligible influence of the glazing type on the cooling energy demand.

4.2 Results for single-panel TFCL 2 system – old type of timber-frame building
4.2. Rezultati za jednopanelni TFCL 2 sustav – stara vrsta građevina drvene konstrukcije

In our further research, we analyse the influence of glazing in the south facade of the old clasic single-panel frame elements, which were massively installed in the seventies and eighties of the last century and present rather large and important segment of the residential fund, which should certaily undergo adequate energy renovation. Marles' single–panel wall element labeled as TFCL 2, whose geometric and material characteristic are shown in Table 1, with thermal transmittance coefficient U_{wall} = 0.48 W/m^{2}K, which is much higher than allowed (see Chapter 3) is taken as an example. The results of the numerical analysis with variable glazing share in the south-oriented facade with the use of triple-pane (TG) and double-layer glazing (DG) are numerically presented in Table 5, and graphically in Figure 6.

Generally, when comparing Figure 5 and Figure 6, the results presented for Q_h, Q_k and the sum Q_h+Q_k show that in the case of the TFCL 2 the glazing type is not so

Table 5 Energy demand for classic single-panel TFCL 2 structural system using three (TG) and double-layer glazing (DG).
Tablica 5. Godišnja energetska potreba za TFCL 2, uz troslojno (TG) i dvoslojno zastakljenje (DG)

TFCL 2 modification South	$A_{glass\ S}/A_{wall\ S}$	Q_h kWh/m^{2}a		Q_k kWh/m^{2}a		$Q_h + Q_k$ kWh/m^{2}a	
		TG	DG	TG	DG	TG	DG
M1S	0.816	35.43	49.94	10.69	11.6	46.12	61.54
M2S	0.610	42.83	55.02	7.27	8.02	50.10	63.04
M3S	0.542	44.90	56.22	6.40	7.09	51.30	63.31
M4S	0.474	46.93	57.38	5.58	6.21	52.51	63.59
M5S	0.407	49.13	58.65	4.82	5.39	53.95	64.04
M6S	0.339	51.44	60.04	4.12	4.61	55.56	64.65
M7S	0.271	53.88	61.57	3.47	3.89	57.35	65.46
M8S	0.203	56.47	63.23	2.88	3.24	59.35	66.47
M9S	0.136	59.22	65.05	2.35	2.64	61.57	67.69
M10S	0.068	61.98	66.89	1.88	2.11	63.86	69.00
M11S	0.000	64.93	68.93	1.47	1.64	66.40	70.57

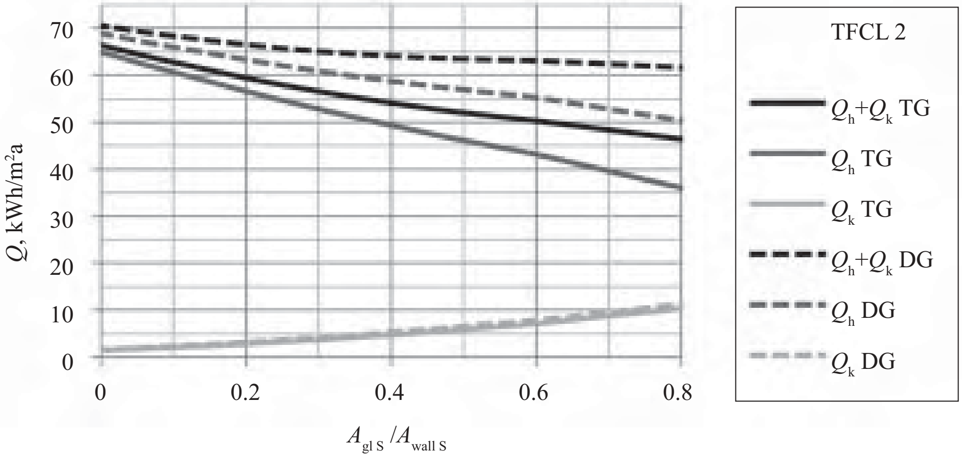


Figure 6 Annual energy demand for classic single-panel TFCL 2 construction system as a function of AGAW for triple-layer (TG) and double-layer glazing (DG).
Slika 6. Godišnja energetska potreba u klasičnome jednopanelnom gradbenom sustavu TFCL 2 kao funkcija AGAW za troslojno (TG) i dvoslojno (DG) zastakljenje

decisive as in the case of TF 3 system. There is practically no influence on the cooling demand at all. In comparison to the TF 3, the functional optimum (lowest Q_h+Q_k value) disappears and the Q_h+Q_k function shows almost linear dependence on AGAW value. The inclination of the function line depends on the glazing type (U_g-value) and it is bigger in the case of the triple-layer glazing (TG). Consequently, in this case, as calculated from Table 5, energy decrease caused by an increase in the total glazing area (measured from AGAW = 0 to AGAW ≈ 0.80) represents 20.28 kWh/m^{2}a or 30.54 %. For the double-layer glazing (DG), these values are 9.03 kWh/m^{2}a or 12.80 %. According to these results, it can be concluded that larger glazing area in the south façade significantly increase energy savings (measured in percents), which are higher for the TFCL 2 system than for the new macro-panel TF 3 system.

4.3. Results for single-panel TFCL 3 system – case of renovation
4.3. Rezultati za jednopanelni TFCL 3 sustav – primjer obnove

As presented in Table 1, the system has been fictively developed from the TFCL 2 old system by inserting an additional layer of insulation in the external side of timber frame. The U_{wall}-value, therefore, decreased from 0.48 W/m^{2}K to 0.30 W/m^{2}K. The results of annual energy demand for heating (Q_h), cooling (Q_k) and the sum (Q_h+Q_k) for the three (TG) and double-layer glazing (DG) as a function of the glazing area size (AGAW = $A_{gl.,S}$ /$A_{wall,S}$) for the south cardinal direction are listed in Table 6 and graphically presented in Figure 7.

The presented results clearly show, just like the TFCL 2, that the glazing type has practically no influence on energy demand for cooling, but the heating function is still essentially bigger in the case of the triple-layer glazing. For the sum of Q_h+$Q_{k,}$ it can be observed that in the case of the double-layer glazing (DG) the optimal point of AGAW appears with AGAW = 0.336 (Table 6). It is interesting that the function dependence on the AGAW is almost constant and the values only vary in the range from 47.36 kWh/m^{2}a at AGAW = AGAW$_{opt}$ = 0.336 to 50.07 kWh/m^{2}a at AGAW = 0. In this case, the total energy demand is practically independent on the size of glazing, which is, of course, very convenient from the economical point of view.

Table 6 Energy demand for fictively improved single-panel TFCL 3 structural system using three (TG) and double-layer glazing (DG).
Tablica 6. Energetska potreba za TFCL 2, uz troslojno (TG) i dvoslojno zastakljenje (DG)

TFCL 3 modification South	$A_{glass\ S}$/$A_{wall\ S}$	Q_h kWh/m^{2}a		Q_k kWh/m^{2}a		$Q_h + Q_k$ kWh/m^{2}a	
		TG	DG	TG	DG	TG	DG
M1S	0.810	23.16	36.87	10.80	11.26	33.96	48.13
M2S	0.606	28.45	40.14	7.14	8.14	35.59	48.28
M3S	0.538	29.89	40.79	6.17	7.17	36.06	47.96
M4S	0.471	31.32	41.40	5.28	6.22	36.60	47.62
M5S	0.404	32.86	42.10	4.44	5.30	37.30	47.40
M6S (opt.for DG)	0.336	34.53	42.92	3.69	4.44	38.22	47.36
M7S	0.269	36.35	43.87	3.00	3.64	39.35	47.51
M8S	0.202	38.31	44.95	2.40	2.92	40.71	47.87
M9S	0.135	40.43	46.17	1.87	2.26	42.30	48.43
M10S	0.067	42.57	47.42	1.42	1.69	43.99	49.11
M11S	0.000	44.89	48.85	1.05	1.22	45.94	50.07

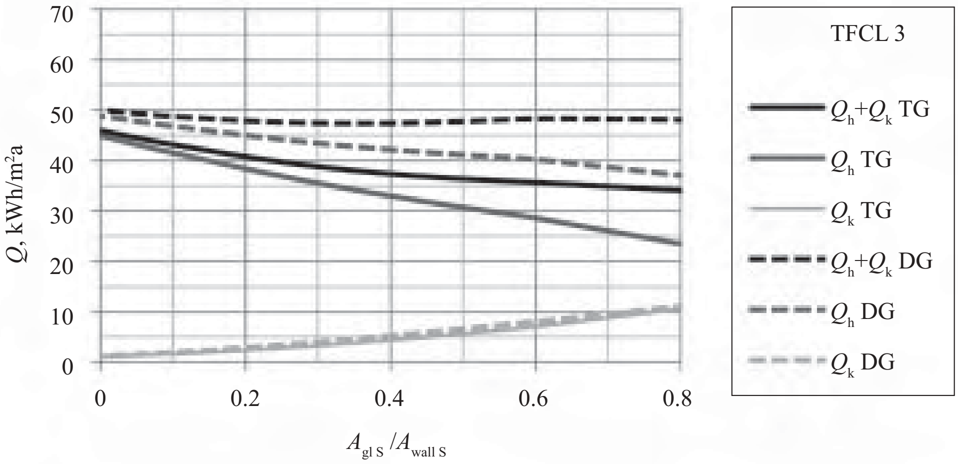


Figure 7 Annual energy demand for the classic single-panel TFCL 3 construction system as a function of AGAW for triple-layer (TG) and double-layer glazing (DG)
Slika 7. Godišnja energetska potreba u klasičnome jednopanelnom gradbenom sustavu TFCL 3 kao funkcija AGAW za troslojno (TG) i dvoslojno (DG) zastakljenje

On the other hand, by using the triple-layer glazing (TG), AGAW does not reach the optimum point, and the enlarged size of glazing still positively effects the total energy demand. Consequently, in this case, as calculated from Table 6, energy decrease caused by an increase in the total glazing area (measured from AGAW = 0 to AGAW ≈ 0.80) represents 11.98 kWh/m²a or 26.08 %. The percentage of energy saving is thus not essentially lower as by TFCL 2 (30.54 %). When comparing the values for TFCL 2 (Table 5) and the values for the renewed TFCL 3 system (Table 6), it is important to point out that by inserting an additional insulation the total energy demand was decreased on an average of about 20 kWh/m²a.

Therefore, if approaching a renovation process only from the point of energy saving and not from an economic viewpoint, the use of the triple-layer glazing is definitely a much better solution. For this reason, findings by Žegarac (2011) should be considered, where the generalisation of the treated energy problem was developed on only one single independent variable (U_{wall}-value). The analysis was performed on the same case study model as in this numerical analyse, using triple-layer glazing only. The possibility of analysing the relationship between the optimal glazing size in south-oriented external wall elements (AGAW$_{opt}$) related to Q_h+Q_k energy demand and thermal transmittance of the wall element (U_{wall}-value) was demonstrated. The data presented in Figure 8 show the values of AGAW, at which the total sum of heating and cooling demand reaches the lowest value, dependant on the U-value of the selected external wall element, independently of the type of construction system.

Figure 8 shows that the optimum or the convergence of the function curves for AGAW$_{opt}$ appears only in systems with the U_{wall}-value ≤ 0.193 W/m²K. A higher U_{wall}-value corresponds to a higher optimal share of the south oriented glazing size. By reaching the limiting U_{wall}-value = 0.193 W/m²K, the values for an optimal AGAW converge towards the maximal glazing surface. For the construction systems with the U_{vall}-value > 0.193 W/m²K no optimum or convergence for

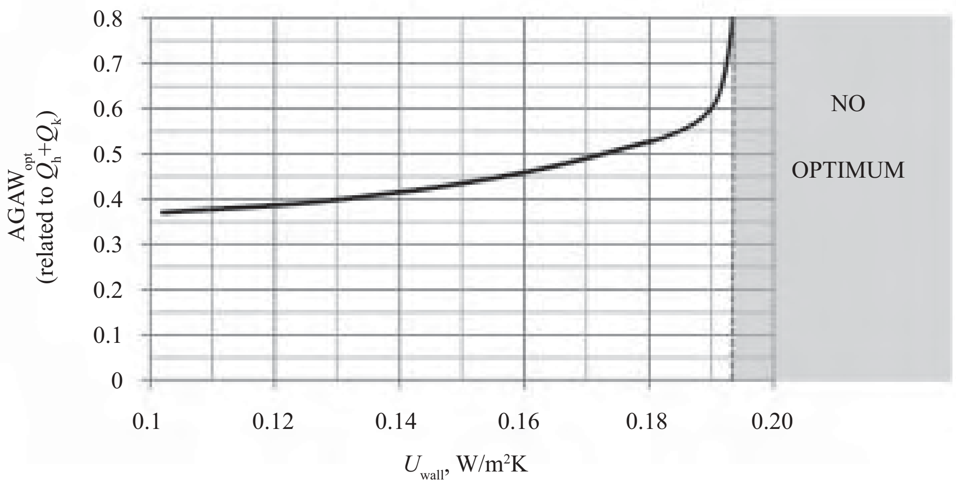


Figure 8 Optimal values of AGAW in the south oriented external wall element as a function of the U_{wall}–value for timber construction systems using triple-layer glazing
Slika 8. Optimalne vrijednosti AGAW u južno orijentiranim vanjskim zidnim elementima kao funkcija U_{wall}–vrijednosti za drvene konstrukcijske sustave koji se koriste troslojnim zastakljenjem

AGAW appear, the lowest Q_h+Q_k is reached at the maximum AGAW value. The whole procedure is widely described by Žegarac Leskovar (2011).

This principle is going to be applicable from a practical point of view in the cases of renovation of old timber houses, where firstly the average U_{wall}-value is reduced with the installation of an additional layer of insulation, and consequently the optimal AGAW value is determined according to the new reduced U_{wall}-value. Finally, the proper size of glazing surfaces can be installed into south-oriented exterior, which contributes to better energy performance of the building.

5 CONCLUSION
5. ZAKLJUČAK

This numerical parametric study shows evidently that in the modern passive prefabricated timber construction (wall system TF 3) double glazing hardly ever pays off regarding energy savings, while triple-layer glazing significantly increases energy savings. Therefore, in order to achieve heating and cooling energy savings in the prefabricated timber-frame structures, built up according to the contemporary passive standards, by installing larger glazing surfaces in the south façade, it is only reasonable to use the glazing of the highest quality, i.e. triple-layer glazing. In the case of the conventional single-panel timber-frame prefabricated timber construction (wall system TFCL 2), which had been used in the seventies and eighties of the last century, nowadays more or less in need of renovation regarding energy efficiency, the type of glazing is much less influential than in the contemporary buildings. Numerical results evidently show that energy savings in the case of triple-layer glazing are higher than in the case of double-layer glazing. However, these differences are much smaller than in the contemporary passive system. In this case, renovation may be a combination of additional insulation and optimal share of south façade glazing. The decision on the choice of the glazing quality is up to the investor, or up to the cost–benefit calculation, i.e. the ratio between the renovation investment and energy savings during future exploitation. As shown in Figure 8, in the case of the triple-layer glazing, from the cost-benefit point of view, it is of prime importance to adequately decrease energy transmittance of the exterior and consequently decrease the share of the glazing surface in the south façade.

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Drying Kinetics of Poplar (*Populus Deltoides*) Wood Particles by a Convective Thin Layer Dryer

Kinetika konvektivnog sušenja tankog sloja iverja drva topole (*Populus Deltoides*)

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ABSTRACT • *Drying of poplar wood (Populus Deltoides) particles was carried out at different drying conditions using a laboratory convective thin layer dryer. Drying curves were plotted and in order to analyze the drying behavior, the curves were fitted to different semi-theoretical drying kinetics models. The effective moisture diffusivity was also determined from the integrated Fick's second law equation and correlated with temperature using an Arrhenius- type model to calculate activation energy of diffusion. The results showed that Midilli et al. model was found to satisfactorily describe the drying characteristics of poplar wood particles dried at all temperatures and air flow velocities. In general, the drying rate increases with increasing air temperature and air flow velocity. A short constant drying rate period was observed and drying frequently took place at falling rate period in all cases. The effective moisture diffusivity of poplar wood particles increased from 1.01E-10 to 2.53E-10 $m^2 \cdot s^{-1}$ as the drying air temperature increased from 65 to 85 °C. The activation energy of diffusion for 1 $m \cdot s^{-1}$ and 1.5 $m \cdot s^{-1}$ air flow velocities were calculated as 27.8 $kJ \cdot mol^{-1}$ and 50.8 $kJ \cdot mol^{-1}$, respectively.*

***Key words**: Poplar wood particles, thin layer dryer, drying kinetics model, effective moisture diffusivity, activation energy*

SAŽETAK • *Pri različitim uvjetima sušenja provedeno je sušenje iverja drva topole (Populus deltoides) uporabom konvektivne sušionice za tanki sloj iverja. Iscrtane su krivulje sušenja, a da bi se analizirao proces sušenja, krivulje su prilagođene različitim teorijskim kinetičkim modelima sušenja. Određena je i efektivna difuznost vode u drvu prema Fickovu drugom zakonu te je primjenom Arrheniusova modela za izračun aktivacijske energije difuzije korelirana s temperaturom. Rezultati su pokazali da model Midillija i suradnika zadovoljavajuće opisuje obilježja sušenja iverja drva topole pri svim temperaturama i brzinama strujanja zraka. U načelu, brzina sušenja povećava se s povećanjem temperature zraka i brzine strujanja zraka. Zabilježeno je kratko razdoblje konstantne brzine sušenja, a sušenje se najčešće postiže u razdoblju pada brzine sušenja. Efektivna difuzivnost vode u iverju drva topole povećana je s 1,01E-10 na 2,53E-10 $m^2 \cdot s^{-1}$ s povećanjem temperature zraka sa 65 na 85 °C. Izračunana je aktivacijska energija difuzije za 1 $m \cdot s^{-1}$ i 1,5 $m \cdot s^{-1}$ brzine strujanja zraka i iznosi 27,8 $kJ \cdot mol^{-1}$ i 50,8 $kJ \cdot mol^{-1}$.*

***Ključne riječi**: iverje drva topole, sušionica tankog sloja iverja, modeli kinetike sušenja, efektivna difuznost vode u drvu, aktivacijska energija*

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1 INTRODUCTION
1. UVOD

In many developing countries, deforestation and over harvesting from poorly managed forests have brought environmental awareness. As a result, focus was placed on studies dealing with the use of implanted wood resources instead of local forest resources for wood composites production. Therefore, fast growing wood resources such as poplar wood are getting more important as a raw material in particleboard and other wood based panel manufacturing.

Drying of wood particles is one of the main steps in a particleboard production process. Consumption of a high amount of energy, apart from environmental impacts, makes it one of the most energy intensive operations with a great importance in particleboard manufacturing. Hence reducing energy consumption, besides product quality, would be highly important for drying the raw materials used in industry.

Investigation of drying kinetics is one of the best methods to get sufficient information about drying performance. Experimental data from the drying curves can be used in simulation of wood particle drying to optimize the particleboard production process.

Thin layer drying equations are important tools in mathematical modeling of drying. They are practical and give sufficiently good results. To use thin layer drying equations, the drying rate curves have to be known. Thin layer drying generally means to dry sample particles or slices in one layer (Akpinar, 2006). The drying performance of hygroscopic materials can be characterized by measuring the changes in the moisture content as a function of time. Drying kinetics data for wood chips in a steam dryer have been determined by Fyhr and Rasmuson (1996). Ceylan (2008) investigated the drying characteristic of poplar and pine timbers in a heat pump dryer, but there is no information available on thin layer drying of poplar wood particles. Laboratory based modeling is needed to characterize the thin layer drying process of poplar wood particles, as full scale studies are both expensive and time consuming (Ghazanfari *et al*., 2006). Therefore, the objectives of this study were to investigate the drying characteristics of poplar wood particles in a hot air convective thin layer dryer and fit the best model for the drying performance of poplar wood particles. In addition, the drying kinetics, moisture effective diffusivities, and activation energies of diffusion at different drying conditions will be computed.

2 MATERIALS AND METHODS
2. MATERIJAL I METODE

2.1 Raw material
2.1. Sirovina

The poplar wood (*Populus Deltoides*) used in this study was supplied from research and educational forest, Khyroudkenar, Noshahr (longitude: 51° 31', Altitude: 36° 39', latitude: -20 m), managed by University of Tehran, Iran. The 20 years old tree trunks were sliced and cut into long strands using an industrial slicer in Rokesh Choobi factory, Gazvin, Iran. The strands were cut into slice shape particles with approximate target dimensions of 1x20x30 mm using a laboratory clipper. The wood particles with the moisture content of around 0.2 kg water/kg dry material were wetted by distilled water to around 1.6 kg water/kg dry material and finally they were kept in sealed plastic bags and stored in a 0-4 °C refrigerator to reach equilibration of moisture content without deterioration, for 72 hours before drying.

2.2 Drying procedure
2.2. Postupak sušenja

The homogeneously moistened wood particles that had been stored in plastic bags, were placed and spread on three perforated trays, in one layer (about 20 g of dry wood particles on each tray), and put into hot air duct on digital balance, which was connected to a computer. Drying experiments were performed at hot air temperatures of 65, 75, and 85 °C with air flow velocities of 1 and 1.5 m·s^{-1} in a laboratory-scale convective thin layer dryer. The initial weight of each sample was measured by an electronic digital balance (GF3000, ±0.02, A& D, Japan). The dryer was set to the selected drying temperatures and air flow velocities for about 30 min to achieve the steady-state conditions before the samples were placed in the duct. The temperatures were measured by means of LM35 sensor (LM35, ±1 °C, NSC, USA), the air flow velocities were measured using an anemometer (V- sensor, 405- VI, ±3 %, TESTO, UK) and the relative humidity of fresh air was measured using a humidity probe (RH-sensor, Capacitive, ± 3 %, PHILIPS, UK). The relative humidity of fresh air was constant (17 %) throughout the experiments. The weight losses of the samples were measured and automatically recorded at 10 second intervals until equilibrium moisture content (EMC) was achieved. Finally, the dried poplar wood particles were put into an oven at 103 ±2 °C for getting equilibrium moisture content. The initial moisture content and equilibrium moisture content were calculated using ASAE, 2001 equations.

2.3 Mathematical modeling of drying and data analysis
2.3. Matematičko modeliranje sušenja i analiza podataka

The form of Newton's law of cooling in heat transfer (equation 1) is often used to describe the moisture loss in thin layer drying (Brooker and Bakker- Arkema, 1974). Based on this law, the drying rate is proportional to the difference in moisture content between the material being dried and the equilibrium moisture content at the drying conditions as:

$$\frac{dM}{dT} = -k(M - M_e) \tag{1}$$

The solution of (1), assuming k is independent of M and M_e, is:

$$MR_{Newton} = \exp(-kt) \tag{2}$$

Where MR is the dimensionless moisture ratio given by:

$$MR = \frac{M - M_e}{M_0 - M_e} \quad (3)$$

In order to determine the moisture ratio as a function of drying time, drying curves obtained in this experiment were fitted with four different models of moisture ratio thin layer drying obtained from the literature (Table 1).

Table 1 Mathematical models applied to the drying curves
Tablica 1. Matematički modeli primijenjeni za krivulje sušenja

Model name *Naziv modela*	**Model equation** *Jednadžba modela*	**Reference** *Referenca*
Newton	$MR=exp(-kt)$	O'Callaghan *et al*., 1971
Page	$MR=exp(-kt^n)$	Pang, 1949
Henderson & Pabis	$MR=a \cdot exp(-kt)$	Guarte, 1996; Chninman, 1984
Midilli *et al*.	$MR=a \cdot exp(-kt^n)+bt$	Midilli *et al*., 2002

The goodness of fit of each model to the experimental data was evaluated from the coefficient of determination (R^2), root mean square error ($RMSE$), reduced chi-square (χ^2), and mean bias error (MBE). R^2 was used as the primary comparison criteria for selecting the best model to fit the four models to the experimental data. Also, a model is considered better than another if it has a lower value of the MBE, $RMSE$, and χ^2. The expressions for each of these parameters are stated as follows:

$$R^2 = \frac{\sum_{i=1}^{N}(M_{R_i} - M_{R_{pre,i}})*(M_{R_i} - M_{R_{\exp,i}})}{\sqrt{\left[(\sum_{i=1}^{N}(M_{R_i} - M_{R_{pre,i}})^2)*(\sum_{i=1}^{N}(M_{R_i} - M_{R_{\exp,i}})^2)\right]}} \quad (4)$$

$$\chi^2 = \frac{\sum_{i=1}^{N}(M_{R_{\exp,i}} - M_{R_{pre,i}})^2}{N - n} \quad (5)$$

$$RMSE = \left[\frac{1}{N}\sum_{i=1}^{N}(M_{R_{pre,i}} - M_{R_{\exp,i}})\right]^{\frac{1}{2}} \quad (6)$$

$$MBE = \frac{1}{N}\sum_{i=1}^{N}(M_{R_{pre,i}} - M_{R_{\exp,i}}) \quad (7)$$

The MBE provides information on the long term performance of the correlations by allowing a comparison of the actual deviation between predicted and measured values term by term. The ideal value of MBE is 'zero'.

3 RESULTS AND DISCUSSION
3. REZULTATI I RASPRAVA

3.1 Experiments of drying kinetics
3.1. Eksperimenti kinetike sušenja

Drying curves for the different temperatures and velocities of hot air in drying poplar wood particles are shown in Figures 1-4. Numerical differentiation of the experimental drying curve data was used to obtain the drying rate curves. Poplar wood particles with an average initial moisture content of around 1.6 kg water/kg dry material were dried to the final moisture content of about 0.008 kg water/kg dry material. It is evident from these curves that the moisture content continuously decreased with the drying time. The drying rate was higher for wood particles dried at higher temperatures than that of particles dried at lower temperatures for the same average moisture content.

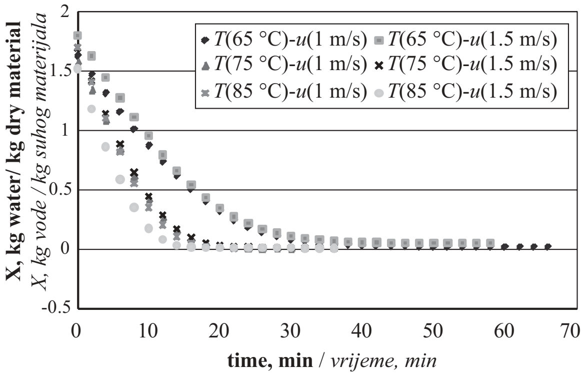

Figure 1 Drying curves (moisture content vs. time) for poplar wood particles under different hot air drying conditions
Slika 1. Krivulje sušenja (sadržaj vode u ovisnosti o vremenu sušenja) za iverje drva topole pri različitim uvjetima sušenja vrućim zrakom

The moisture ratio of samples reduced exponentially as the drying time increased. These curves show an increase of drying rate, given by the curve slope, with an increase in temperature (Figure 1). This is in agreement with the results of the previous studies (Mazza and Maguer, 1980; Lopez *at al*., 2000). At higher temperatures, the relative humidity of the drying air was less than that of the drying air at lower temperatures. Hence, the difference in the partial vapor pressure between the surface of wood particles and the surrounding drying air at higher temperatures would be higher than the one at lower temperatures. Consequently, the moisture transfer rate is increased at higher temperature (Kaleemullah and Kailappan, 2005).

Figures 1 and 2 clearly show that the air temperature along with air velocity had a significant effect on the moisture content of the samples. Drying process is not only more rapid at higher temperatures but also faster at higher velocities (Figure 3). During the experiments of hot air drying, the time to reach the final moisture content for the samples was found to be between 27 and 67 min at different drying conditions. An increase in the air temperature and air velocity resulted in an increase in the drying rate and consequently a decrease in the drying time. Previous studies have reported similar trends (Ertekin and Yaldiz, 2004; Fritzell *et al*., 2009; Ghazanfari *et al*., 2006). As can be seen, drying rate at the initial stage of the drying period is rather low, which may be due to the activation energy and increase of the temperature of wood water content. At

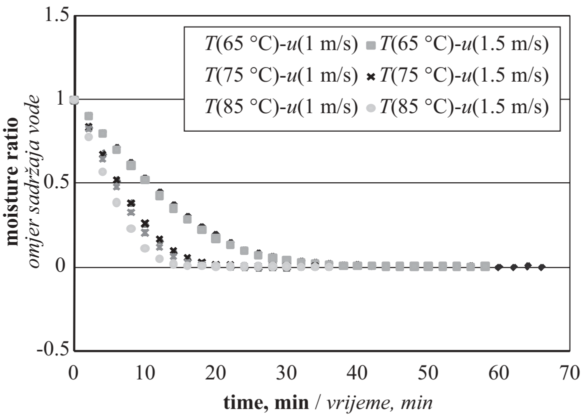

Figure 2 Drying curves (moisture ratio vs. time) for poplar wood particles under different hot air drying conditions
Slika 2. Krivulje sušenja (sadržaj vode u ovisnosti o vremenu sušenja) za iverje drva topole pri različitim uvjetima sušenja vrućim zrakom

the beginning, when the moisture content was high, the drying rate was very high, and as the moisture content approached the equilibrium moisture content, the drying rate was very low (Figure 2). This is in good agreement with the results of Kaleemullah and Kailappan (2005), Lopez *et al*. (2000) and Mazza and Maguer (1980).

Drying rate vs. average moisture content curves (Krischer curves) for wood particles at different drying air temperatures are shown in Figure 4. To eliminate the scattering of curves, each drying rate curve was smoothed using a second-order polynomial (Kemp et al., 2001).

Generally, the product is dried at a constant rate, and for hygroscopic products, after a falling rate period, the decrease stops and the equilibrium is established. As shown in Figure 4, all drying periods can be observed in the curves for poplar wood particles made by Krischer. At the early stage of drying, known as the induction period, the wet solid temperature rises to a constant (equilibrium) value (Montazer-Rahmati and Amini-Horri, 2001) then, a short constant rate period begins. In the constant rate period of drying, external conditions such as temperature, air flow velocity, relative humidity of the medium and physical form of the wood particles control the drying process and the surface diffusion is the dominant diffusion mechanism. Toward the end of the constant rate period, moisture has to be transported from the inside of the solid material to the surface by capillary forces and the drying rate may still be constant until the moisture content has reached the critical moisture content, and the surface film of the moisture has been so reduced that dry spots appear on the surface. Then the first falling rate period or unsaturated surface drying begins. Since, however, the rate is computed with respect to the overall solid surface area, the drying rate falls even though the rate per unit of wet solid surface area remains constant (Menon, 1995). In this drying period, liquid diffusion is the dominant diffusion mechanism due to moisture concentration difference and internal conditions such as moisture content, temperature, and wood particles structure. When the surface film of the liquid is entirely evaporated, the subsequent falling rate period begins. In the second falling rate period of drying, vapor diffusion is the dominant diffusion mechanism as moisture concentration difference and internal conditions are still very important (Husain *et al*., 1972).

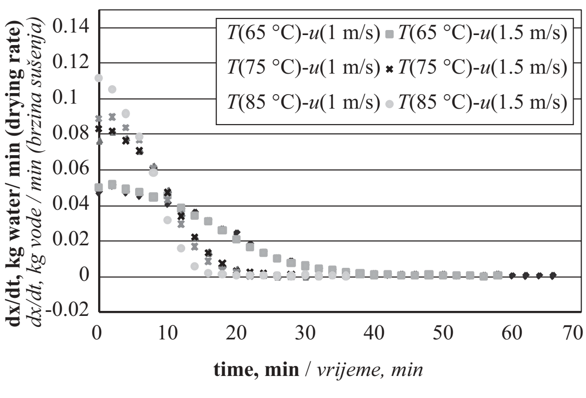

Figure 3 Drying rate curves for poplar wood particles under different hot air drying conditions
Slika 3. Krivulje brzine sušenja iverja drva topole pri različitim uvjetima sušenja vrućim zrakom

Referring to the curves, the critical point is approximately 1.4 kg water/kg dry material. This high critical moisture content is attributed to the hygroscopicity of wood substance. As mentioned above, wood particles did not show a distinct constant rate period throughout the drying process (Figure 4) and drying mostly took place in the falling rate period. Pang *et al*. (1997), Husain *et al*. (1972) and Fritzel *et al*. (2009) show in their investigations that there was a constant rate period during the drying of veneer and wood fibers. Bakshi and Singh (1980) state that although biological materials have high moisture content, generally no constant rate period is seen in the drying processes. Similar results have been presented by Chandy *et al*. (1992), Freire *et al.* (2001), Kaleemullah and Kailappan (2005) and Vijayaraj *et al.* (2007). Although materials are generally dried without a constant rate period, Erbay and Icier (2010) state that sometimes there is an overall constant rate period at the initial stages of drying. The short constant rate period that can be seen at the beginning of the drying process may be attributed to evaporation of superficial water, retained on the surface of wood particles after removing the excessive water, making the sample surfaces wet during this period.

3.2 Fitting of the drying curves
3.2. Prilagodba krivulja sušenja

So far, numerous models have been proposed to describe the behavior of thin layer drying kinetics. In this study, four different models were fitted to the experimental drying curve data at different drying conditions (Table 1). The results of the statistical analysis and the estimated values of the parameters for these models have been listed in Table 2. The results show that all the four models gave a good fit to the experimental data with a value greater than 0.96 for R^2. Among the models, the Midilli *et al*. model showed the

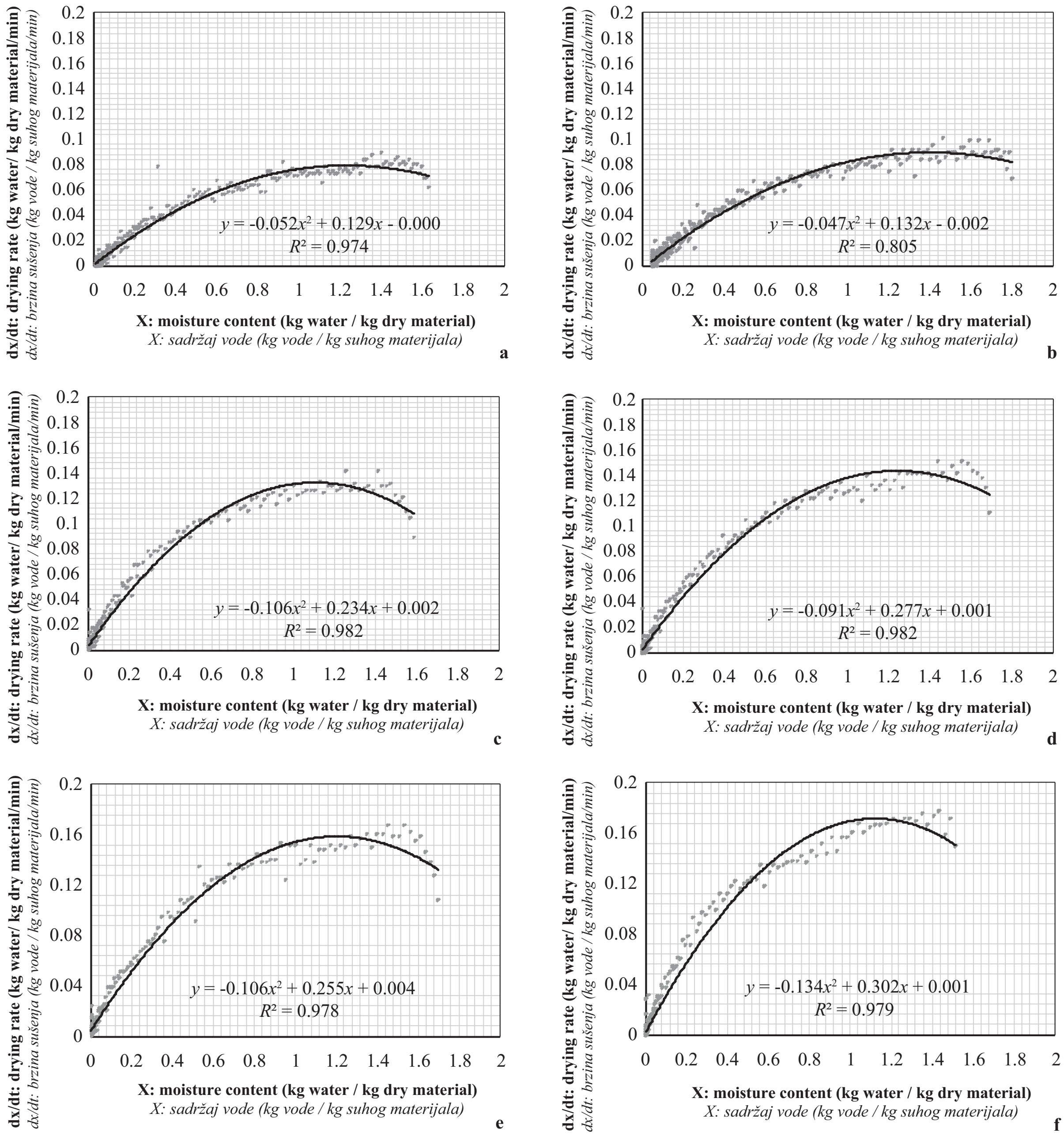

Figure 4 Krischer curves for poplar wood particles drying. a) T= 65 °C, u= 1m·s^{-1}; b) T= 65 °C, u= 1.5 m·s^{-1}; c) T= 75 °C, u= 1 m·s^{-1}; d) T= 75 °C, u= 1.5 m·s^{-1}; e) T= 85 °C, u= 1 m·s^{-1}; f) T= 85 °C, u= 1.5 m·s^{-1}
Slika 4. Krischerove krivulje sušenja iverja drva topole: a) T= 65 °C, u= 1m·s^{-1}; b) T= 65 °C, u= 1,5 m·s^{-1}; c) T= 75 °C, u= 1 m·s^{-1}; d) T= 75 °C, u= 1,5 m·s^{-1}; e) T= 85 °C, u= 1 m·s^{-1}; f) T= 85 °C, u= 1,5 m·s^{-1}

best fit (R^2 > 0.99) followed by the Page, Henderson & Pabis and Newton models. Also, the values for *RMSE*, χ^2 and *MBE* attained from the Midilli *et al*. model were less than the values from other models generally followed by the Page, Henderson & Pabis and Newton models. Therefore, the Midilli *et al*. model was considered the best model to represent the behavior of thin layer drying of poplar wood particles within the experimental range of this study (Table 2).

To account for the effect of the drying variables on the Midilli *et al*. model constants *k*, *a*, *b* and coefficient *n*, the predicted values were correlated as a function of drying air temperature and air flow velocity using multiple regression analysis (Eqs. 9-11). Based on this analysis, the Midilli *et al*. model constants and coefficient were expressed in terms of drying air temperature *T* (°C) and air flow velocity *u* (m·s^{-1}) as:

$$MR = a\cdot\exp(-kt^n) + b\cdot t \quad (8)$$

$$k = -0.11569 + 0.001718\cdot T + 0.014\cdot u \quad (9)$$

$$a = 0.9699 - 2.5\cdot 10^{-5} - 0.00622\cdot u \quad (10)$$

$$n = 1.3798 + 0.002458\cdot T - 0.0522\cdot u \quad (11)$$

$$b = -0.00077 + 7.99\cdot 10{-}6\cdot T + 0.000016\cdot u \quad (12)$$

These functions can be used to estimate the moisture ratio of poplar wood particles with a high accuracy and are valid for the above mentioned conditions.

Table 2. Statistical analysis for the four models at different drying conditions
Tablica 2. Statistička analiza za četiri modela kinetike sušenja pri različitim uvjetima sušenja

Drying condition *Uvjeti sušenja*		Model *Model*	Model parameter *Parametri modela*	R^2	*RMSE*	χ^2	*MBE*
T, °C	*u*, m·s⁻¹						
65	1	Newton	*k*=0.078	0.977	0.04263	0.001822	0.006951
		Page	*k*=0.028, *n*=1.373	0.999	0.010607	0.000113	0.001124
		Henderson & Pabis	*a*=1.119, *k*=0.086	0.986	0.033157	0.001105	0.010399
		Midilli *et al.*	*a*=0.961, *k*=0.021, *n*=1.46, *b*=3.39E-5	0.999	0.00765	5.91E-05	0.00138
65	1.5	Newton	*k*=0.081	0.977	0.043715	0.001917	0.007439
		Page	*k*=0.03, *n*=1.364	0.999	0.00963	9.33E-05	0.002838
		Henderson & Pabis	*a*=1.117, *k*=0.089	0.986	0.033799	0.001149	0.011824
		Midilli *et al.*	*a*=0.964, *k*=0.023, *n*=1.436, *b*=7.2E-5	1	0.007277	5.36E-05	0.003065
75	1	Newton	*k*=0.133	0.967	0.054237	0.002957	0.009375
		Page	*k*=0.049, *n*=1.449	0.998	0.054237	0.002973	0.00491
		Henderson & Pabis	*a*=1.136, *k*=0.149	0.98	0.042116	0.001793	0.014393
		Midilli *et al.*	*a*=0.965, *k*=0.04, *n*=1.522, *b*=0.0	0.999	0.008869	8.03E-05	0.002949
75	1.5	Newton	*k*=0.135	0.974	0.045899	0.002116	0.009049
		Page	*k*=0.055, *n*=1.405	0.998	0.011272	0.000128	0.004173
		Henderson & Pabis	*a*=1.123, *k*=0.15	0.984	0.036185	0.001321	0.011928
		Midilli *et al.*	*a*=0.959, *k*=0.043, *n*=1.497, *b*=9.6E-5	0.999	0.007993	6.50E-05	0.00018
85	1	Newton	*k*=0.149	0.967	0.054877	0.00303	0.008771
		Page	*k*=0.059, *n*=1.438	0.998	0.01267	0.000163	0.005302
		Henderson & Pabis	*a*=1.132, *k*=0.166	0.998	0.042968	0.001869	0.014854
		Midilli *et al.*	*a*=0.965, *k*=0.049, *n*=1.505, *b*=0.0	0.999	0.009844	9.94E-05	0.003714
85	1.5	Newton	*k*=0.181	0.975	0.041127	0.001699	0.007482
		Page	*k*=0.081, *n*=1.413	0.998	0.012093	0.000148	0.004051
		Henderson & Pabis	*a*=1.121, *k*=0.20	0.984	0.033194	0.001112	0.009962
		Midilli *et al.*	*a*=0.952, *k*=0.062, *n*=1.528, *b*=5.45E-5	0.999	0.0092	8.62E-05	0.000312

The accuracy of the established model was evaluated by comparing the computed moisture ratios with the observed values as shown in Figure 5. The close agreement between the measured and the predicted moisture contents gives confidence in applying the model to examine the influence of wood particles variables and drying conditions on the drying rate.

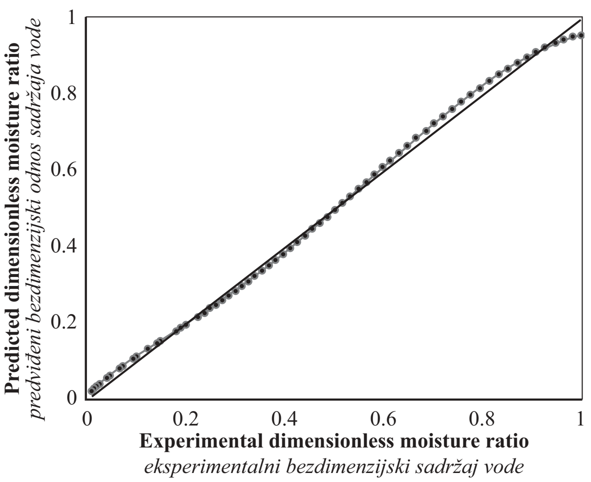

Figure 5 Experimental moisture ratio vs. predicted moisture ratio from Midilli *et al.* model for constant *T*=85 °C, *u*=1.5 m·s⁻¹
Slika 5. Eksperimentalni sadržaj vode u odnosu na predviđeni omjer sadržaja vode prema modelu Midillija i suradnika za konstante *T*=85 °C, *u*=1,5 m·s⁻¹

3.3 Calculation of effective moisture diffusivity and activation energy of diffusion
3.3. Izračun efektivne difuznosti vode u drvu i aktivacijske energije difuzije

In describing a drying process during the falling rate period, the concept of effective moisture diffusivity (D_{eff}) has been accepted as the basic mechanism of moisture movement inside the drying material (Reyes *et al*. 2004). As mentioned in the previous sections, the drying of wood particles mostly occurs in the falling rate period and liquid diffusion controls the process. Fick's second law of diffusion can be used to model the drying behavior of wood particles. The following analytical solution for diffusion in an infinite planar slab was given by Akpinar, 2006:

$$MR = \frac{M}{M_o} = \frac{8}{\pi^2}\sum_{n=1}^{\infty}\frac{1}{(2n-1)^2}\exp\left[-\frac{(2n-1)^2\pi^2 Dt}{4L^2}\right] \quad (13)$$

Only the first term of equation (6) is used for long drying times (Lopez *et al*., 2000), hence:

$$MR = \frac{8}{\pi^2}\exp\left[-\frac{\pi^2 Dt}{4L^2}\right] \quad (14)$$

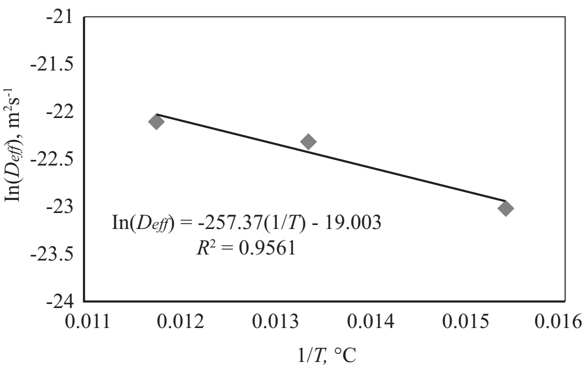

Figure 6 Relationship between the effective moisture diffusivity (D_{eff}) and the reciprocal of absolute temperature (1/*T*)
Slika 6. Odnos između efektivne difuznosti vode u drvu (D_{eff}) i recipročne vrijednosti apsolutne temperatura (1/*T*)

From equation (7), a plot of ln(*MR*) versus time gives a straight line with a slope of k_o given by:

$$k_0 = \frac{\pi^2 D}{4L^2} \qquad (15)$$

The activation energy of diffusion was calculated using an Arrhenius type equation (Akpinar *et al*., 2003; Lopez *et al*., 2000):

$$D = D_0 \exp\left[-\frac{E_a}{RT_a}\right] \qquad (16)$$

Where E_a is the energy of activation (kJ·mol^{-1}), *R* is universal gas constant (8.3143 kJ·mol^{-1} K), T_a is absolute air temperature (*K*), and D_o is the pre-exponential factor of the Arrhenius equation (m^2·s^{-1}). The activation energy can be determined from the slope of the Arrhenius plot, ln(*D*) versus $1/T_a$. From Equation (9), a plot of ln(*D)* versus $1/T_a$ gives a straight line whose slope is k_1, given by:

$$k_1 = \frac{E_a}{R} \qquad (17)$$

In the above equations, isothermal assumption was used and *T* is the ambient air temperature of the dryer duct.

The effective moisture diffusivity D_{eff} of poplar wood particles increased from 1.01E-10 to 2.53E-10 m^2·s^{-1} as the drying air temperature increased from 65 to 85 °C, and increased from 1.69E-10 to 2.03E-10 m^2·s^{-1} as the air flow velocity increased from 1 to 1.5 m·s^{-1}. As can be deduced, the effect of hot air temperature on effective moisture diffusivity is higher than that of air flow rate. The plot depicting the relationship between ln(D_{eff}) and 1/*T* was found to be a straight line in the range of temperatures investigated, indicating Arrhenius dependence (Figure 6). The activation energy of diffusion E_a for 1 m·s^{-1} and 1.5 m·s^{-1} air velocity were also calculated as 27.8 kJ·mol $^{-1}$ and 50.8 kJ·mol $^{-1}$, respectively.

4 CONCLUSION
4. ZAKLJUČAK

At the end of this study, the following conclusions can be drawn:

The Midilli *et al*. model is quite suitable for predicting the drying curve behavior of poplar wood particles in the temperature range of 65-85 °C.

Constant drying rate period is very short in any of the experiments and the drying process of the poplar wood particles is mostly carried out at the falling rate period.

Effective moisture diffusivity of poplar wood particles increases with increasing air temperature and air flow velocity in the range of 1.01E-10 to 2.53E-10 m^2·s^{-1}.

The activation energy of diffusion for 1 m·s^{-1} and 1.5 m·s^{-1} air flow velocities were calculated as 27.8 kJ·mol $^{-1}$ and 50.8 kJ·mol $^{-1}$, respectively.

5 NOMENCLATURE
5. OPIS ZNAKOVA

a, n, b Dimensionless drying constants in drying models / *bezdimenzionalne konstante u modelima sušenja*
k Drying velocity constant in drying models (min^{-1}) / *konstanta brzine sušenja u modelima sušenja*
L Particles half thickness (m) / *polovica debljine iverja*
M Moisture content at any time (% dry basis) (kg water/ kg dry material) / *trenutačni sadržaj vode (% u odnosu prema suhome materijalu) (kg vode / kg suhog materijala)*
MBE Mean bias error / *srednja pogreška*
MR Moisture ratio / *omjer sadržaja vode*
R Universal gas constant (8.3143 kJ mol^{-1}·K^{-1}) / *opća plinska konstanta*
N Total number of observation / *ukupni broj zapažanja*
n Number of constants / *broj konstanti*
n Number of terms / *broj uvjeta*
R^2 Coefficient of determination / *koeficijent determinacije*
RH Relative humidity in drying chamber / *relativna vlažnost zraka u sušionici*
RMSE Root mean square error / *korijen srednje kvadratne pogreške*
D Diffusivity (m^2·s^{-1}) / *difuznost*
E Energy (kJ·mol^{-1}) / *energija*
T Temperature (°C) (°K) / *temperatura*
t Time (min) / *vrijeme*
u Air flow velocity (m·s^{-1}) / *brzina strujanja zraka*
x Moisture content (kg water / kg dry material) / *sadržaj vode u drvu (kg/vode / kg suhog materijala)*

Greek symbols
χ^2 Reduced chi- square / *reducirani Hi-kvadrat*

Subscripts
0 Initial / *početno stanje*
i *i*th order / *i-ti red*
crit Critical / *kritično*
e Equilibrium / *ravnoteža*
exp Experimental / *eksperimentalni*
a Activation / *aktivacija*
a Air / *zrak*
eff Effective / *efektivno*
m Mean / *prosječno*
pre Predicted / *predviđeno*

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Modeli osiguranja tvrtki drvnog sektora

Insurance Models of Wood Sector Companies

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SAŽETAK • *Ciljevi istraživanja bili su utvrditi kako su osigurane tvrtke drvnog sektora i od kojih se opasnosti osiguravaju. Promatrani su parametri bili: struktura osiguranja, veličina tvrtki, tehnološke mogućnosti s određenom potrebom njihova osiguranja te ukupna sigurnost tvrtki drvog sektora koja se odnosi na imovinu i imovinske interese. Rezultati istraživanja pokazali su kako se drvne tvrtke koriste uslugama osiguravajućih društava, ali ne dovoljno. Pokazalo se kako osigurane tvrtke koje su pretrpjele velike štete imaju veće izglede za sanaciju šteta te kako je poželjno da se primjene određeni modeli osiguranja jer je trošak premije osiguranja u strukturi ukupnih troškova gotovo zanemariv i nije poželjno na tome štedjeti jer osiguranje donosi potrebnu sigurnost, koja je nužna u tvrtkama drvnog sektora. Analizom i usporedbom dobivenih rezultata predstavljeni su i obrazloženi modeli osiguranja koji će biti najučinkovitiji.*

Ključne riječi: *tvrtke drvnog sektora, osiguranje, rizik, klaster analiza, modeli*

ABSTRACT • *The research goals were to determine how the wood sector companies were insured and which risks were covered by insurance. The following parameters were studied: the structure of insurance, company size, technological capabilities requiring insurance coverage, and the overall security of wood sector companies with respect to property and property interests. The results have shown that the wood sector companies use the services of insurance companies but not to a sufficient extent. It has been shown that companies that had suffered great damage have greater security for the recovery of damage. It has also been shown that insurance models should be applied since the share of insurance premium costs in the total cost structure is almost negligible and that saving on these costs is not desirable taking into consideration that it brings the necessary security to the wood sector companies. By analyzing and comparing the obtained results, insurance models that would be the most effective have been presented and elaborated.*

Key words: *wood sector companies, insurance, risk, cluster analysis, models*

1. UVOD
1 INTRODUCTION

Osiguranje imovine i imovinskih interesa postaje nezaobilazno i gotovo obvezujuće. Preuzimanje rizika bez osiguranja vodi u veliku neizvjesnost. Uočava se trend rasta i proširenja osiguravateljskih pokrića, odnosno sve veća potreba da se rizik smanji na minimalnu mogućih mjera, jer to postaje jedan od preduvjeta sigurnog poslovanja. Potpuno je razumljivo da su poduzetnici svjesni svih rizika poslovanja, osobito onih koji mogu utjecati na opstanak i sigurnost poslovanja. Osiguranje imovine i imovinskih interesa dobiva sve važniju ulogu i u drvnoj industriji. Tvrtke drvnog sektora posjeduju sve veću pokretnu i nepokretnu imovinu koja je izložena raznim rizicima. Određeni je broj tvrtki zbog tehnoloških procesa i zahtjeva proizvodnje prisiljen kupovati sve skuplju tehnologiju te osigurati kontinuitet proizvodnje. Većinu rizika moguće je po-

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kriti određenim policama osiguranja i tako smanjiti rizik, za što je potrebno platiti odgovarajuću premiju osiguranja. Pojam rizika u poslovanju odavno je poznat. Sve veća globalizacija svjetskog tržišta i ubrzani razvoj svjetskih tehnologija prate i osiguravatelji te su danas pokrića što ih oni nude izuzetno široka i omogućuju tvrtkama drvnog sektora da rizike koji bi mogli ugroziti opstojnost preuzme netko drugi, tj. su osiguravateljske kuće.

Mnogi autori (Andrijanić i Klasić, 2002; Andrijašević i Petranović, 1999; Bijelić, 2002; Rejda, 2011) tvrde da pojam i značenje osiguranja imovine i imovinskih interesa, na žalost, još nije dovoljno ozbiljno prihvaćen jer osiguranje imovine nije obvezno propisano zakonom. Određen broj tvrtki preuzima rizik neosiguranja imovine, čime tvrtke, ako nastanu velike štete, zapadaju u položaj koji je za njih teško rješiv. Važnost osiguranja sve je veća, što je vidljivo i iz sve većeg broja menadžera i brokera koji posreduju između osiguravateljskih tvrtki i tvrtki kojima je potrebna osiguravateljska zaštita za pokrivanje rizika poslovanja.

Vrijednost tvrtki uvijek je u opasnosti od različitih rizika. Rizici u poslovanju tvrtki drvnog sektora mogu biti različiti, i to od malih do velikih. Da bi se navedene opasnosti smanjile, tvrtke je potrebno kvalitetno osigurati policama osiguranja. Osiguranje imovine dostupno je svima i nije toliko skupo da bi potencijalne korisnike odbijalo svojom cijenom. Štoviše, osiguranje ulazi u kategoriju malih troškova koji mogu biti izuzetna pomoć pri štetnom slučaju koji bi mogao narušiti poslovanje tvrtke (Koprolčec, 2012).

Ciljevi našeg istraživanja bili su:

- definirati obilježja tvrtki drvnog sektora, i to za tvrtke koje proizvode namještaj, za tvrtke koje obavljaju primarnu i sekundarnu proizvodnju te za trgovine namještajem
- utvrditi kako su tvrtke do sada bile osigurane poslije zadnje tri godine
- utvrditi kako osiguranje imovine i imovinskih interesa utječu na sigurnost poslovanja
- utvrditi razinu sigurnosti u razmjeru s pokrivenošću policama osiguranja
- formirati modele osiguranja u tvrtkama drvnog sektora.

2. MATERIJAL I METODE
2 MATERIAL AND METHODS

U istraživanju je sudjelovalo 300 poslvnih subjekata koji su na temelju Nacionalne klasifikacije djelatnosti razvrstani na područja: C – Prerađivačka industrija, odjeljak 16 – Prerada drva i proizvoda od drva i pluta, s pripadajućim razredima 16. 10 – Piljenje i blanjanje drva, 16. 2 – Proizvodnja proizvoda od drva, pluta, slame i pletarskih materijala, odjeljak C 31 – Proizvodnja namještaja s pripadajućim razredima 31. 01 – Proizvodnja namještaja za poslovne i prodajne prostore, 31. 02 – Proizvodnja kuhinjskog namještaja, 31. 03 – Proizvodnja madraca, 31. 09 – Proizvodnja ostalog namještaja i odjeljak 46 – Trgovina na veliko s pripadajućim razredima, 46. 13 – Posredovanje u trgovini drvom i građevinskim materijalom 46. 15 – Posredovanje u trgovini namještajem.

Prikupljanje podataka provedeno je putem anketnog upitnika. Anketni je upitnik razvijen prema prethodno definiranim ciljevima istraživanja, koji su uključivali mišljenja o osiguranju imovine i imovinskih interesa unutar hrvatskih tvrtki drvnog sektora.

Sve varijable definirane su višestrukim tvrdnjama, jer je utvrđeno kao će se određena varijabla/element bolje opisati primjenom višestrukih tvrdnji nego samo jednom tvrdnjom (Pirc, 2011).

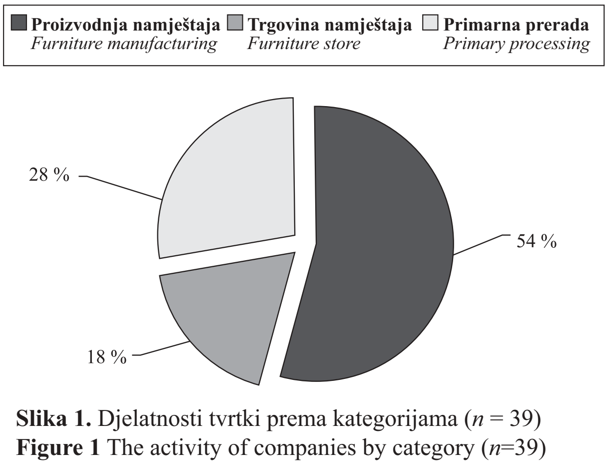
Određene varijable mjerene su primjenom Likertove ljestvice od pet stupnjeva (Five-point Likert scale) tako da su uz tvrdnje pojedinih varijabli bili navedeni rasponi od 1 do 5, pri čemu 1 označava ‘uopće se ne slažem’ ili ‘nevažno’, a 5 znači ‘u potpunosti se slažem’ ili ‘vrlo važno’, tj. ispitanici su određivali stupanj zadovoljstva ili značenja koji pridaju pojedinim tvrdnjama. Nadalje, određene su varijable mjerene tako da su pojedine tvrdnje definirane u obliku da/ne pitanja. Anketni je upitnik sadržavao i pitanja o općim informacijama potencijalnih ispitanika/poslovnih subjekata, dok su pojedina pitanja definirana uz pomoć višestrukih tvrdnji ili u obliku da/ne tvrdnji (Pirc, 2011).

Anketni je upitnik poslan na e-mail adrese svih 300 odabranih poslovnih subjekata. Ukupan broj vraćenih i pravilno ispunjenih anketnih upitnika čiji su podaci korišteni u daljnjoj analizi iznosio 39, odnosno konačni je odaziv ispitanika iznosio 16,05 %. Podaci iz anketnih upitnika unosili su se u bazu podataka, u tablicu programa *Microsoft Excel,* a statistička analiza provedena je primjenom statističkog programa *SPSS Statistics*.

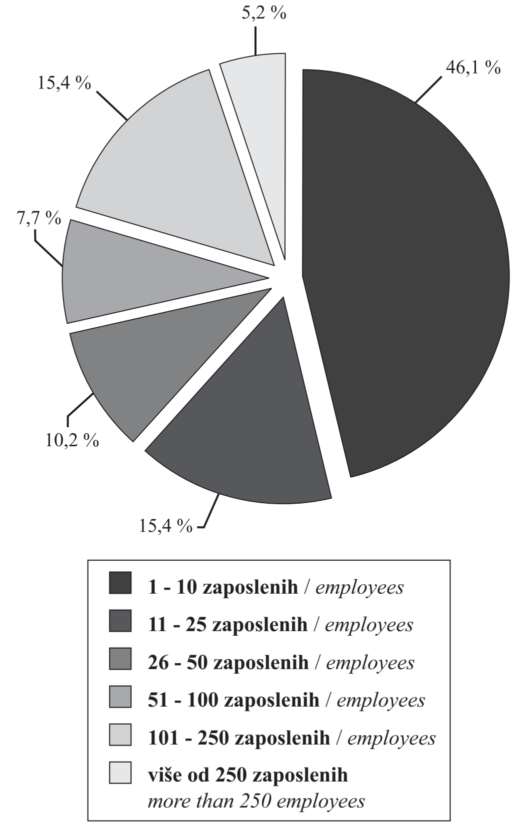
3. REZULTATI I RASPRAVA
3 RESULTS AND DISCUSSION

Od 39 ispitanika 54 % njih izjasnilo se kako se njihova tvrtka bavi proizvodnjom namještaja, 28 % primarnom preradom drva,a 18 % ispitanika izjasnilo se kako se njihova tvrtka bavi trgovinom namještaja (sl. 1).

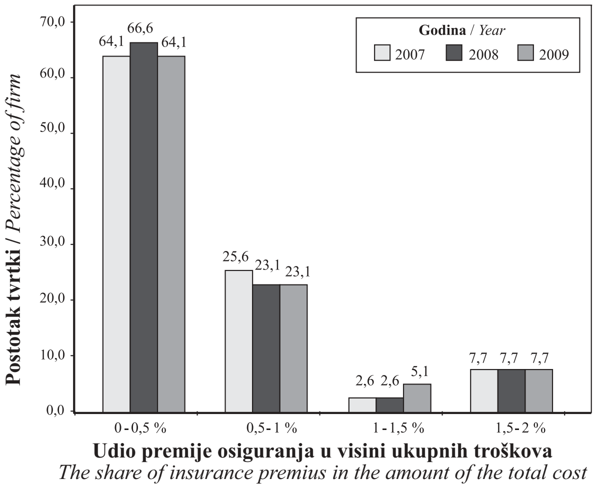
Na pitanje o broju i strukturi zaposlenika, oko polovica ispitanika, točnije 46,1 %, odgovorilo je da u svojim tvrtkama zapošljava do 10 osoba, 15,4 % ispita-



Slika 1. Djelatnosti tvrtki prema kategorijama (n = 39)
Figure 1 The activity of companies by category (n=39)



Slika 2. Broj zaposlenika u tvrtkama (n = 39)
Figure 2 Number of employees in a company (n = 39)



Slika 3. Udio premije osiguranja u ukupnim troškovima tvrtki drvnog sektora (n = 39)
Figure 3 The share of insurance premiums in the amount of the total costs of wood sector companies (n = 39)

nika zapošljava od 11 do 25 osoba, dok od 26 do 50 zaposlenika zapošljava 10,2 % ispitanih tvrtki. U 7,7 % ispitanih tvrtki radi između 51 i 100 osoba, dok njih 15,4 % zapošljava između 101 i 250 osoba. Više od 250 osoba zapošljava 5,2 % ispitanih tvrtki (slika 2).

Na pitanje o udjelu premije osiguranja u ukupnim troškovima za 2007. godinu 64,1 % tvrtki navodi da je on iznosio manje od 0,5 %, 25,6 % ispitanika navodi da je taj udio bio u rasponu od 0,5 do 1,0 %, za 2,6 % ispitanika taj je udio bio u rasponu od 1 do 1,5 %, a 7,7 % ispitanika navodi da se udio kretao u rasponu od 1,5 do 2 % ukupnih troškova. Za 2008. i 2009. godinu situacija je bila vrlo slična, što pokazuje slika 3.

Na pitanje sklapa li tvrtka police osiguranja 89,7 % njih izjasnilo se pozitivno, a samo 10,3 % negativno, a na pitanje osigurava li tvrtka imovinu i imovinske interese potvrdno je odgovorilo 87 %, a 13 % izjavilo je da se tvrtka ne osigurava. Tablica 1. pokazuje koliko je tvrtki (u postotku) u 2007, 2008. i 2009. godini sklopilo police osiguranja i koje su to police bile.

U tablici 2. predočena je ukupna vrijednost osiguranja imovine u razdoblju od tri navedene godine za sve tvrtke koje su odgovorile na anketu. U svakoj od djelatnosti najveći iznos osigurane imovine odnosi se na zaštitu od požara i požarnih rizika. Takav je model najzastupljeniji u djelatnosti trgovine, gdje se 86 % svega što je osigurano odnosi na osiguranje od požara. Kvar stroja sljedeća je vrsta osiguranja koje sklapaju tvrtke drvnog sektora. U djelatnosti primarne i sekundarne proizvodnje drvnih proizvoda potres zauzima treće mjesto.

Tablica 1. Police osiguranja tvrtki u 2007, 2008. i 2009. godini (n = 39)
Table 1 Companies insurance policies in 2007, 2008 and 2009 (n = 39)

Polica osiguranja … / *Insurance policy against…*	**postotak tvrtki** / *percentage of companies*		
	2007.	2008.	2009.
od požara i požarnih rizika / *fire and fire risk*	85 %	85 %	85 %
od kvara stroja / *machine crash*	41 %	44 %	44 %
od provalne krađe / *burglary*	44 %	44 %	39 %
od loma stakla / *breakage of glass*	36 %	36 %	36 %
od potresa / *earthquake*	26 %	26 %	23 %
od prekida rada (*šomaža*) / *downtime*	3 %	3 %	3 %
od odgovornosti / *liability*	38 %	36 %	36 %
računala i računalne opreme / *computers and computer equipment*	36 %	36 %	36 %
robe u zakupu / *goods leased*	10 %	10 %	10 %
od štete u proizvodnji / *indemnity in the production process*	10 %	10 %	13 %
od proizvođačke odgovornosti / *producer responsibility*	13 %	13 %	10 %
kasko vozila / *collision car*	72 %	72 %	67 %
kasko vozila s kvarom stroja / *collision car with machine crash*	15 %	15 %	15 %

Tablica 2. Vrijednosti predmeta osiguranja – prosjek od 2007. do 2009. godine (n = 39)
Table 2 The value of insurance – average from 2007 to 2009 (n = 39)

Vrste osiguranja *Types of insurance*	**Vrijednost osigurane imovine u kn (prosjek 2007-2009)** *Value of insured property in HRK (average 2007-2009)*				**Udio osigurane imovine (prosjek 2007-2009)** / *Share of insured property (average 2007-2009)*			
	proizvodnja namještaja i ostalih proizvoda od drva *Manufacture of furniture and other wood products*	trgovina namještaja i drvnih proizvoda *Furniture store and wood products*	proizvodnja primarnih i sekundarnih drvnih proizvoda *Production of primary and secondary wood products*	ukupno *Total*	proizvodnja namještaja i ostalih proizvoda od drva *Manufacture of furniture and other wood products*	trgovina namještaja i drvnih proizvoda / *Furniture store and wood products*	proizvodnja primarnih i sekundarnih drvnih proizvoda *Production of primary and secondary wood products*	ukupno *Total*
požar / *fire*	36.375.059,40	52.634.476,14	29.553.879,80	118.563.415,34	66 %	86 %	61 %	71 %
kvar stroja *machine crash*	12.837.044,14	6.227.330,14	9.850.181,18	28.914.555,46	23 %	10 %	20 %	18 %
potres *earthquake*	2.034.340,97	728.571,43	6.599.935,09	9.362.847,49	4 %	1 %	14 %	6 %
odgovornost *responsibility*	2.574.146,29	85.714,29	346.363,64	3.006.224,21	5 %	0 %	1 %	2 %
kasko vozila *collision car*	626.871,43	295.142,86	502.983,91	1.424.998,19	1 %	0 %	1 %	1 %
prekid rada *downtime*	-	-	1.385.211,10	1.385.211,10	0 %	0 %	3 %	1 %
krađe *burglary*	126.190,48	840.714,29	48.272,73	1.015.177,49	0 %	1 %	0 %	1 %
računala *computers*	358.559,34	116.571,43	61.431,49	536.562,26	1 %	0 %	0 %	0 %
lom stakla *breakage of glass*	27.656,87	107.571,43	24.000,00	159.228,30	0 %	0 %	0 %	0 %
kasko s kvarom stroja *collision car with machine crash*	9.464,95	136.142,86	16.329,55	161.937,35	0 %	0 %	0 %	0 %
štete u proizvodnji *indemnity in the production process*	17.142,86	-	15.000,00	32.142,86	0 %	0 %	0 %	0 %
zakup roba *goods leased*	-	17.142,86	-	17.142,86	0 %	0 %	0 %	0 %
proizvođačka odgovornost *producer responsibility*	-	-	-	-	0 %	0 %	0 %	0 %
Ukupno *Total*	54.986.476,73	61.189.377,71	48.403.588,47	164.579.442,91	100 %	100 %	100 %	100 %

3.1. Klaster analiza
3.1 Cluster analysis

Klaster analiza metoda je koja je u našem primjeru omogućila cjeloviti pogled na ponašanje tvrtki s obzirom na njihove unutarnje činitelje poslovanja. Cilj klasterizacije bio je dobiti optimalan broj klastera tvrtki koje se razlikuju po bitnim obilježjima. U analizi su korišteni ovi pokazatelji poslovanja tvrtke: prihodi tvrtke, ukupni troškovi tvrtke, broj zaposlenih u tvrtki i osnovna djelatnost tvrtke. Za klaster analizu korištene su vrijednosti za 2009. godinu. Iako postoje podaci o troškovima za 2007, 2008. i 2009, u njima nema značajnijih odstupanja, pa su korišteni podatci za 2009.

Finalna klaster analiza na temelju navedenih čimbenika rezultirala je dvama klasterima. Distribucija klastera prikazana je u tablici 7.

S obzirom na pokazatelje poslovanja, dobiveno rješenje klasterizacije dijeli tvrtke na dva klastera.

Tablica 3. Prihodi tvrtke 2009. (*n* = 39) – naknadno kreirane skupine za potrebu klaster analize
Table 3 Revenues in 2009 (*n* = 39) – groups created subsequently for cluster analysis

Kategorije prihoda *Categories of income*	**Broj tvrtki** / *Number of companies*
do / *to* 5.000.000 kn	18
do / *to* 1.000.000 kn	8
1.000.000 - 5.000.000 kn	10
više od / *more than* 5.000.000 kn	21
5.000.000 – 10.000.000 kn	8
10.000.000 – 20.000.000 kn	3
20.000.000 – 40.000.000 kn	5
više od / more than 40.000.000 kn	5
Ukupno / *Total*	39

Tablica 4. Troškovi tvrtke 2009. (*n* = 39) – naknadno kreirane skupine za potrebu klaster analize
Table 4 Costs in 2009 (*n* = 39) – groups subsequently created for cluster analysis

Kategorije troškova *Categories of income*	**Broj tvrtki** *Number of companies*
do / *to* 5.000.000 kn	19
do / *to* 1.000.000 kn	12
1 - 5.000.000 kn	7
više od / *more than* 5.000.000 kn	20
5.000.000 - 10.000.000 kn	6
10.000.000 - 20.000.000 kn	4
20.000.000 - 40.000.000 kn	6
više od / more than 40.000.000 kn	4
Ukupno / *Total*	39

Tablica 5. Broj zaposlenih 2009. (*n* = 39) – naknadno kreirane skupine za potrebu klaster analize
Table 5 Number of employees in 2009 (*n* = 39) – groups subsequently created for cluster analyfor cluster analysis

Broj zaposlenih *Number of employees*	**Broj tvrtki** *Number of companies*
1 do 10 zaposlenih *1 to 10 employees*	18
1 - 10	18
11 do 50 zaposlenih *11 to 50 employees*	10
11 - 25	6
26 - 50	4
više od 50 zaposlenih *more than 50 employees*	11
51 - 100	3
101 - 250	6
više od 250 / *more than 250*	2
Ukupno / *Total*	39

3.1.1. Klaster 1 – male tvrtke
3.1.1 Cluster 1 – Small companies

Tvrtke tog klastera uglavnom imaju do 10 zaposlenih (84 %). Sve tvrtke iz tog klastera imale su prihode manje od 5 milijuna kuna, s tim da je većina od 84 % imala prihode manje od milijun kuna. Ukupni troškovi većine tvrtki u 2009. ne prelaze milijun kuna

Tablica 6. Osnovna djelatnost tvrtke (*n* = 39) – naknadno kreirane skupine za potrebu klaster analize
Table 6 The main activity of the company (*n* = 39) – groups subsequently created for cluster analyfor cluster analysis

Djelatnost tvrtki *Activity of companies*	**Broj tvrtki** *Number of companies*
proizvodnja namještaja i ostalih proizvoda od drva / *manufacture of furniture and other wood products*	21
trgovina namještaja i drvnih proizvoda / *furniture store and wood products*	7
proizvodnja primarnih i sekundarnih drvnih proizvoda / *production of primary and secondary wood products*	11
Ukupno / *Total*	39

Tablica 7. Distribucija klastera (*n* = 39)
Table 7 Distribution of clusters (*n* = 39)

Klasteri *Clusters*	**Broj tvrtki** *Number of companies*	**Postotak tvrtki** *Share of companies* %
klaster 1 / *Cluster 1*	19	48,7
klaster 2 / *Cluster 2*	20	51,3
Ukupno u klasterima / *Total of clusters*	39	100,0

(63 %), dok ostale tvrtke iz klastera imaju troškove između milijun i 5 milijuna kuna.

Tvrtke iz prvog klastera uglavnom se bave proizvodnjom namještaja i ostalih proizvoda iz od drva (58 %). Približno četvrtina tvrtki bavi se proizvodnjom primarnih i sekundarnih drvnih proizvoda, dok se ostale (16 % njih) bavi trgovinom namještaja i drvnih proizvoda. Većina tih tvrtki osnovana je u razdoblju od 1991. do 2000. godine, njih 63 %, a samo jedna prije 1991. Jednako tako, u usporedbi s tvrtkama iz klastera 2, u ovoj je skupini tvrtki znatno više onih koje su osnovane nakon 2000. godine.

3.1.2. Klaster 2 – velike tvrtke
3.1.2 Cluster 2 – Big companies

Sedamdesetpet posto tvrtki u ovom klasteru (75 %) ima više od 25 zaposlenih. Prihodi svih tvrtki u 2009. veći su od 5 milijuna kuna, s tim da su najbrojnije one s 5 do 10 milijuna kuna ostvarenih prihoda. Troškovi svih tvrtki iz drugog klastera u 2009. prelaze 5 milijuna kuna. Iako su uglavnom osnovane tijekom 1990-ih (60 %), u usporedbi s tvrtkama iz klastera 1. znatno je više onih koje su osnovane prije 1991, točnije četvrtina.

Tvrtke iz klastera 2. više se bave proizvodnjom namještaja i ostalih proizvoda od drva, zatim proizvodnjom primarnih i sekundarnih drvnih proizvoda, dok ih je najmanje u skupini trgovine namještaja i drvnih proizvoda, samo 20 %.

3.1.3. Osiguranje i klasteri
3.1.3 Insurance and clusters

Dobiveni klasteri tvrtki razlikuju se prema rezultatima s obzirom na udio troškova osiguranja u ukupnim troškovima tvrtke. U tablici 8. prikazana je distri-

Tablica 8. Udio premije osiguranja prema klasterima (n = 39)
Table 8 The share of insurance premiums by clusters (n = 39)

Udio premije osiguranja u troškovima 2009 *The share of insurance premium in costs in 2009*	**Klaster 1 - broj tvrtki** / *Cluster 1 – number of companies*	**Klaster 1 - udio tvrtki** / *Cluster 1 – share of companies*	**Klaster 2 - broj tvrtki** / *Cluster 2 – number of companies*	**Klaster 2 - udio tvrtki** / *Cluster 2 – share of companies*
do / *to* 0,5 %	15	78,9 %	10	50,0 %
0,5 - 1 %	2	10,5 %	7	35,0 %
1 - 1,5 %	0	0,0 %	2	10,0 %
više od / *more than* 1,5 %	2	10,5 %	1	5,0 %
Ukupno / *Total*	19	100,0 %	20	100,0 %

Tablica 9. Vrijednost osigurane imovine klastera (n = 39)
Table 9 The value of insured property of clusters (n = 39)

	Klasteri *Clusters*	*N*	**Prosječna vrijednost** *Average value* kn	**Standardna devijacija** *Standard deviation*	**Standardna pogreška aritmetičke sredine** *Standard error of the average value*	**Vrijednost *t*** *Value of t*	**Vrijednost *p*** *Value of p*
Vrijednost osigurane imovine 2007. / *Value of insured property in 2007*	1	19	2.653.188,19	3.576.900,63	820.597,28	-3,073	0,006
	2	20	32.265.919,30	42.941.616,69	9.602.037,40		
Vrijednost osigurane imovine 2008. / *Value of insured property in 2008*	1	19	2.069.912,77	2.737.592,51	628.046,80	-3,220	0,004
	2	20	33.223.682,91	43.182.838,15	9.655.976,16		
Vrijednost osigurane imovine 2009. / *Value of insured property in 2009*	1	19	1.642.050,00	1.640.447,03	376.344,36	-3,188	0,005
	2	20	34.237.560,80	45.698.266,54	10.218.443,04		

bucija udjela unutar klastera za tvrtke iz klastera 1. udio premije osiguranja u ukupnim troškovima uglavnom iznosi do 0,5 %. Većini tvrtki iz klastera 2. udio za premije osiguranja također iznosi do 5 %, ali ih je znatno više u skupini čiji troškovi za premije osiguranja iznose više od 0,5 % ukupnih troškova.

Vrijednost osigurane imovine tvrtki iz klastera 1. znatno je manja u svim promatranim godinama. Značajnost razlike u iznosima troškova po godinama provjerena je *t*-testom za nezavisne uzorke. U sva tri promatrana razdoblja vrijednost osigurane imovine klastera 2. znatno je veća od one klastera 1. (p<0,05). Rezultati su prikazani u tablici 9.

Očekivano, iznosi štete u tvrtkama iz prvoga i dugog klastera nastale u promatranom razdoblju (tabl. 10) također se značajno razlikuju (p<0,05). Prosječni iznosi šteta nastali u tvrtkama iz klastera 2. višestruko nadvisuju one nastale u klasteru 1. Zanimljivo je i da u tvrtkama iz klastera 1. nije zabilježena nijedna šteta nastala u 2007. godini.

Klasteri se također razlikuju i s obzirom na prosječan broj ugovorenih premija. Kada se promatra stanje u 2009. godini, tvrtke iz klastera 1. u prosjeku imaju 2,26 ugovorenih premija, dok je broj ugovorenih premija u tvrtkama iz klastera 2. znatno veći i iznosi 5,95 (p<0,05). Rezultati testiranja t-testom za nezavisne uzorke prikazani su u tablici 11.

Klasteri se razlikuju i prema vrijednosti osigurane imovine. U klasteru 1. prosječna vrijednost osigurane imovine doseže 6,4 milijuna kuna, dok je u klasteru 2. prosječna vrijednost višestruko veća i iznosi 99,7 milijuna kuna.

Tablica 10. Iznosi šteta klastera (n = 39)
Table 10 Cluster damages (n = 39)

	Klasteri *Clusters*	*N*	**Prosječna vrijednost** *Average value* kn	**Standardna devijacija** *Standard deviation*	**Standardna pogreška aritmetičke sredine** / *Standard error of the average value*	**Vrijednost *t*** *Value of t*	**Vrijednost *p*** *Value of p*
Iznos šteta 2007. *Amount of damages in 2007*	1	19	-	-	-	-2,377	0,028
	2	20	70.338,59	132.364,19	29.597,53		
Iznos šteta 2008. *Amount of damages in 2008*	1	19	157,89	688,25	157,89	-2,360	0,029
	2	20	100.558,90	190.230,65	42.536,87		
Iznos šteta 2009. *Amount of damages in 2009*	1	19	102,33	446,04	102,33	-3,610	0,002
	2	20	97.736,06	120.933,38	27.041,53		

Tablica 11. Prosječan broj ugovorenih premija (n = 39)
Table 11 The average number of contracted premium (n = 39)

	Klasteri *Clusters*	*N*	**Prosječna vrijednost** *Average value*	**Standardna devijacija** *Standard deviation*	**Standardna pogreška aritmetičke sredine** *Standard error of the average value*	**Vrijednost *t*** *Value of t*	**Vrijednost *p*** *Value of p*
Prosječan broj ugovorenih premija / *Average number of contracted premium*	1	19	2,2632	2,18180	0,50054	37,000	0,000
	2	20	5,9500	3,33206	0,74507		

3.1.4. Štete i klasteri
3.1.4 Damages and clusters

Uz razlike u vrijednosti osigurane imovine, tvrtke u klasterima 1. i 2. razlikuju se i prema visini šteta zabilježenih u razdoblju od 2007. do 2009. godine. Tako ukupan iznos šteta u navedenom razdoblju u tvrtkama klastera 1. iznosi 4.944,25 kuna, dok je iznos šteta u tvrtkama iz klastera 2. čak 5.372.670,89 kuna. Treba napomenuti da je broj tvrtki u klasterima gotovo jednak, u prvome je 19, a u drugome 20 tvrtki.

U tablici 12. dana je struktura vrijednosti ugovorenih polica osiguranja, odnosno njihov udio u ukupnoj osiguranoj vrijednosti, te udio iznosa šteta prema pojedinim stavkama. Kad se ukupna vrijednost osigurane imovine tvrtki iz klastera 1. (6,4 miliuna kuna) podijeli iznosima pojedinih polica, dobiva se podatak da su gotovo tri četvrtine vrijednosti osigurane imovine osigurane od požara, zatim slijede osiguranje od potresa i odgovornosti. Za tvrtke iz klastera 2. situacija je nešto drugačija. Iako se i u njima većina vrijednosti osigurane imovine (99,7 milijuna kuna) odnosi na osiguranje od požara (69 % ukupne vrijednosti osigurane imovine), ostatak osigurane vrijednosti odnosi se na vrijednost osiguranja od kvara strojeva. Potres je na trećemu mjestu, i od njega je osigurano 5 % ukupno osigurane imovine.

Upravo je u vezi sa strojolomom zamjetna razlika u udjelu vrijednosti imovine osigurane od tog rizika i iznosa šteta nastalih zbog strojoloma. Naime, od ukupnog iznosa trogodišnjih šteta nastalih u tvrtkama iz klastera 2., najveći se dio odnosi na štete nastale zbog kvara strojeva, čak 43 % ukupnog iznosa, dok vrijednost imovine osigurane od kvara strojeva čini samo 1 % ukupne vrijednosti osigurane imovine. Osim strojoloma, razmjerno najveće štete u tvrtkama iz klastera 2 nastale su zbog požara, zatim odgovornosti, *šomaža* i kasko osiguranja vozila. Tvrtke iz klastera 1. nisu imale velikih šteta, najveću štetu izazvale su im krađe i troškovi kasko osiguranja vozila.

3.2. Modeli osiguranja
3.2 Insurance models

Podaci o učestalosti šteta nastalih u promatranim tvrtkama i troškova prouzročenih tim štetama također idu u prilog vrijednosti ulaganja u policu osiguranja. Ti su pokazatelji navedeni u tablici 13.

Iz podataka u tablici 13. vidljivo je da se za tvrtke u drvnoj industriji nužno osigurati od šteta koje se

Tablica 12. Udio vrste osiguranja u ukupnim štetama (n = 39)
Table 12 The share of total insurance claims (n = 39)

Vrsta osiguranja *Type of insurance*	**KLASTER 1** / *CLUSTER 1*		**KLASTER 2** / *CLUSTER 2*	
	Udio u ukupnoj vrijednosti polica osiguranja / *Share of total value of insurance policies*	Udio u ukupnim štetama *Share in total damages*	Udio u ukupnoj vrijednosti polica osiguranja / *Share of total value of insurance policies*	Udio u ukupnim štetama *Share in total damages*
požar / *fire*	74 %	0 %	69 %	17 %
potres / *earthquake*	12 %	0 %	5 %	0 %
odgovornost / *responsibility*	9 %	0 %	2 %	12 %
kasko vozila / *collision car*	3 %	39 %	1 %	9 %
krađe / *burglary*	1 %	61 %	0 %	3 %
kvar stroja / *machine crash*	1 %	0 %	21 %	43 %
lom stakla / *breakage of glass*	0 %	0 %	0 %	0 %
roba zakup / *goods leased*	0 %	0 %	0 %	0 %
računala / *computers*	0 %	0 %	0 %	0 %
kasko s lomom stroja / *collision car with machine crash*	0 %	0 %	0 %	3 %
proizvođačka odgovornost *producer responsibility*	0 %	0 %	0 %	0 %
prekid rada / *downtime*	0 %	0 %	1 %	11 %
štete u proizvodnji / *indemnity in the production process*	0 %	0 %	0 %	1 %

Tablica 13. Učestalost štetnih događaja (n = 39)
Table 13 The frequency of adverse events (n = 39)

Vrsta štete *Type of damages*	**Broj tvrtki koje su imale štetu** *Number of companies that have had damage*	**Udio tvrtki sa štetama u ukupnom uzorku** *Share of companies with damages in the total sample*	**Iznos nastale štete** *Amount of damage* kn
kvar stroja / *machine crash*	9	23 %	2.314.866,37
požar / *fire*	5	13 %	918.508,22
odgovornost / *responsibility*	4	10 %	659.300,00
prekid rada / *downtime*	1	3 %	617.116,45
kasko vozila / *collision car*	10	26 %	493.594,50
krađe / *burglary*	4	10 %	163.437,70
kasko vozila & kvar stroja / *collision car with machine crash*	4	10 %	158.754,00
štete u proizvodnji / *indemnity in the production process*	1	3 %	30.876,22
računala / *computers*	2	5 %	18.310,99
lom stakla / *breakage of glass*	1	3 %	2.850,69
potres / *earthquake*	0	0 %	-
zakup robe / *goods leased*	0	0 %	-
proizvođačka odgovornost / *producer responsibility*	0	0 %	-

događaju izrazito često i/ili od događaja koji izazivaju velike štete u poslovanju tvrtke. Najbolji je primjer kvar strojeva koji je zabilježen u čak 23 % tvrtki i koji je tijekom trogodišnjeg razdoblja prouzročio štete od 2,3 milijuna kuna. Prema učestalosti pojavljivanja (u jednoj od deset tvrtki) visoko su rangirani požar, šteta na vozilu, odgovornost, krađe te kasko i kvar stroja. Navedene nepredviđene situacije uzrokovale su 2,39 milijuna kuna štete, otprilike kao kvarovi strojeva. *Šomaž* se pojavljuje u samo jednoj od tvrtki u ovom istraživanju, ali je iznos nastale štete (više od 600 000 kn) razlog za uključivanje tog rizika u model osiguranja u drvnoj industriji.

Kada se uzme u obzir visoka vjerojatnost pojave navedenih neplaniranih događaja i visina štete koju mogu prouzročiti, te premijske stope za te tipove osiguranja i udio takvog ulaganja u ukupnim troškovima tvrtke, ugovaranje nekoga od modela osiguranja nameće se kao dobra poslovna odluka i jamstvo kontinuiteta uspješnog poslovanja.

3.2.1. Model 1.
3.2.1 Model 1

Unutar tvrtki obuhvaćenih istraživanjem svaka je osma imala štetu nastalu zbog požara i/ili *šomaža*. Visina iznosa takvih šteta u promatranom je razdoblju premašila 1,5 milijun kuna. Udio tvrtki koje su doživjele takav oblik štete visok je, dok je premija koja bi iznosila približno 0,5‰ vrijednosti osigurane imovine bila oko 200 000 kn. Analizirane su tvrtke koje su imale štetu u trogodišnjemu promatranom razdoblju.

3.2.2. Model 2.
3.2.2 Model 2

Četvrtina tvrtki u trogodišnjem je razdoblju pretrpjela štetu zbog požara, *šomaža* ili kvara stroja. Ukupni iznos nastalih šteta iznosio je 3,85 milijuna kuna i prouzročen je na osiguranoj imovini vrijednoj 534 milijuna kuna. Premijske stope u tom slučaju znatno variraju, ali i u najgorem bi slučaju bile 1 ‰, dakle premija bi bila oko pola milijuna u godini. Kada se taj iznos uspo-

Tablica 14. Model 1.
Table 14 Model 1

MODEL 1. Požar i prekid rada (*šomaž*) *MODEL 1. Fire and downtime*				
Broj tvrtki koje su imale štetu / *Number of companies that have had damage*	Vjerojatnost nastanka štete / *Probability of an event of damage*	Iznos nastale štete *Amount of damage*	Vrijednost osigurane imovine / *Value of insured property*	Premijske stope *Premium rates*
5	1:7,8	1.535.625 kn	406.530.75 kn	od 0,25‰ do 1‰

Tablica 15. Model 2.
Table 15 Model 2

MODEL 2. Požar i *šomaž* te kvar stroja *MODEL 2. Fire and downtime and machine crash*				
Broj tvrtki koje su imale štetu *Number of companies that have had damage*	Vjerojatnost nastanka štete *Probability of an event of damage*	Iznos nastale štete *Amount of damage*	Vrijednost osigurane imovine / *Value of insured property*	Premijske stope *Premium rates*
10	1:3,9	3.850.491 kn	534.005.08 kn	od 0,25 do 13,05 ‰

Tablica 16. Model 3.
Table 16 Model 3

MODEL 3. Požar i *šomaž* te kvar stroja i odgovornost *MODEL 3. Fire and downtime and machine crash and responsibility*				
Broj tvrtki koje su imale štetu / *Number of companies that have had damage*	Vjerojatnost nastanka štete *Probability of an event of damage*	Iznos nastale štete *Amount of damage*	Vrijednost osigurane imovine *Value of insured property*	Premijske stope *Premium rates*
10	1:3,9	4.509.791 kn	547.584.11 kn	od 0,25 do 13,05 ‰ odgovornost ovisno o broju zaposlenika / *responsibility depending on the number of employees*

redi s iznosom štete prouzročene nekim od tri uzroka navedena u modelu 2, jasno je da je premija osiguranje prema modelu 2. dobro rješenje za tvrtke drvne industrije, posebice one koje se bave proizvodnjom i koriste se strojevima velike vrijednosti. Analizirane su tvrtke koje su imale štetu u trogodišnjemu promatranom razdoblju.

3.2.3. Model 3.
3.2.3 Model 3

Unutar modela 3 predviđena su osiguranja od požara, *šomaža*, kvara stroja i odgovornosti. Ukupni iznos nastalih šteta iznosio je 4,51 milijun kuna, dok je vrijednost imovine osiguranika (10 tvrtki koje su imale štetu) koji su stradali procijenjena na 547,58 milijuna kuna. Kao i u prethodnim analizama, visina rizika (prema rezultatima istraživanja jedna od deset tvrtki imala je barem jednu od navedenih šteta obuhvaćenih modelom 3) i visina premijske stope koja je u modelima povoljnija za osiguranika ide u prilog tezi da je za drvnu industriju osiguranje jamstvo neometanog poslovanja. Analizirane su tvrtke koje su imale štetu u trogodišnjemu promatranom razdoblju.

4. ZAKLJUČAK
4 CONCLUSION

Promatrajući štetne događaje nastale u razdoblju od 2007. do 2009. godine zamjetno je da je najviše šteta pretrpjela proizvodnja namještaja i ostalih proizvoda od drva, ponajprije zbog požara i požarnih rizika, i to u iznosu od 1.753.914 kn, a u prosječnom udjelu osigurane imovine to čini 51 % vrijednosti te osigurane imovine. Druga šteta po visini proizašla je iz odgovornosti i iznosi 617.116 kn, a u prosječnom udjelu osigurane imovine to čini 39 % vrijednosti.

Štetni događaji pretežito su posljedica iz požara i požarnih rizika, a najveća je zastupljenost osiguranja upravo od požara i požarnih rizika. U ukupnoj premiji osiguranja 66 % premije u proizvodnji namještaja otpada na osiguranje od požara i požarnih rizika, 80 % na prodaju namještaja, a 61 % na primarnu preradu drva.

U tvrtkama drvnog sektora u razdoblju od 2007. do 2009. godine, iznos vrijednosti osigurane imovine bio je znatno veći u tvrtkama koje su imale prihod veći od 5 000 000 kn, a trend se nastavio i u 2008. godinu (t=-3,22; p=0,004; t=-2,36; p=0,029) te u 2009, u kojoj je visina nastale štete također bila znatno veća u tvrtkama koje su u tom razdoblju ostvarile prihod veći od 5 mil. kuna (t=3,61; p=0,002).

Tvrtke koje su za plaćanje premije izdvojile više od 0,5 % svojih ukupnih izdataka imaju i veći iznos osigurane imovine te trpe veće štete, premda ne statistički značajne. Taj se trend proteže od 2007. do 2009. godine.

Preporuka koja proizlazi iz prikupljenih podataka i obavljene analize govori u prilog tezi da je osiguranje imovine i imovinskih interesa potreba i trošak koji nije uputno izbjegavati nesklapanjem police osiguranja, a potrebno je primijeniti jedan od ponuđenih modela. Predloženi modeli za promatrani tip tvrtki jesu:
- model 1: požar + *šomaž*
- model 2: požar + *šomaž* i kvar stroja
- model 3: požar + *šomaž* i kvar stroja i odgovornost.

To vrijedi uz napomenu kako svaka tvrtka treba uvidjeti razinu koju želi postaviti kao zaštitu za neometani tijek poslovanja. Podatak da 23 % tvrtki drvnog sektora pretrpi štetu zbog kvara stroja obvezujući je podatak koji govori o potrebi sklapanja takvih vrsta polica osiguranja, a 26 % tvrtki pretrpjelo je štetu zbog nepostojanja kasko osiguranja i svakako valja uzeti u obzir kako bi se takve police osiguranja trebale sklapati. Samo jedna šteta od *šomaža* u iznosu od 617.116 kn nameće tu vrstu osiguranja gotovo kao obvezu jer samo jedna takva šteta definitivno može biti kobna za opstanak tvrtke drvnog sektora ako ona ne bi imala to osiguranje. Osiguranje od požara, udjelom od 13 % u štetama promatranih tvrtki ukazuje o velikoj vjerojatnosti izbijanja šteta iz požarnih rizika tako da bi i takve police trebale sklapati s osiguravateljskim kućama.

Na razini ukupnog uzorka, štete obuhvaćene modelom 3. čine čak 83,9 % vrijednosti svih nastalih šteta. Po djelatnostima to izgleda ovako:
- proizvodnja namještaja – 79,9 % vrijednosti svih nastalih šteta obuhvaća model 3.
- trgovina namještaja – 79,6 % vrijednosti svih nastalih šteta obuhvaća model 3.
- proizvodnja primarnih i sekundarnih drvnih proizvoda – 93,4 % vrijednosti svih nastalih šteta obuhvaća model 3.

Može se zaključiti da model 3. pokriva 80 % šteta.

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Selected Ratio and Bankruptcy Early-Warning Method Analysis of Competitiveness of Wood Sector Companies Listed on Warsaw Stock Exchange

Analiza konkurentnosti tvrtki drvnog sektora koje su na Varšavskoj burzi metodom odabranog omjera i ranog upozorenja o bankrotu

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ABSTRACT • *This paper presents the analysis of economic conditions of wood sector companies listed on the Warsaw Stock Exchange. Among many measures of ratio analysis, the three most frequently used groups of indicators - profitability, debt and liquidity were selected. For a comprehensive presentation of the situation of each company, the Mączyńska & Zawadzki's model was used as the bankruptcy early warning method. Two furniture industry companies, two wood-based panel industry companies, two pulp and paper industry entities, a representative of sawmilling industry and a company of wood-based panels and furniture industry were analyzed. The analysis showed that companies with stabile position in the market have the best economic conditions, and these were namely the pulp and paper industry and furniture industry.*

Keywords: *ratio analysis, bankruptcy early-warning methods, competitiveness, wood sector companies*

SAŽETAK • *Ovaj rad sadrži analizu ekonomskih uvjeta u tvrtkama drvnog sektora koje se nalaze na Varšavskoj burzi. Među mnogim metodama mjerenja i analize omjera odabrane su tri najčešće skupine indikatora – profitabilnost, dugovanja i likvidnost. Za sveobuhvatnu prezentaciju situacije u pojedinoj tvrtki u proračunavanju ranog upozorenja bankrota odabran je model Maczynska & Zawadzki. Analizirane su dvije tvrtke proizvodnje namještaja, dvije trtke za proizvodnju drvnih ploča, dvije tvrtke u području proizvodnje pulpe i papira, jedan predstavnik pilana i jedna tvrtka koja proizvodi i namještaj i drvne ploče. Analiza je pokazala da najbolje ekonomske uvjete imaju tvrtke sa stabilnom pozicijom na tržištu među koje pripadaju tvrtke za proizvodnju pulpe i papira te za proizvodnju namještaja.*

Ključne riječi: *analiza omjera, metode ranog upozorenja bankrota, konkurentnost, tvrtke drvnog sektora*

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1 INTRODUCTION
1. UVOD

Taking cooperation with a contractor in any kind of project or investing funds in a company shares is a very important decision to be made by the investor. The results of this decision may affect the amount of profits, losses and may even determine decisions taken by the company management in the subsequent periods. To reduce the probability of making wrong decisions, a potential investor can use a variety of proven and frequently used methods (Jelačić *et al*., 2006). One of the most used and best known method is: ratio analysis - an element of financial analysis and a more powerful tool – the discriminant analysis using early warning models (Sedliačikova *et al*., 2006). Financial data are the best indication of company problems, especially the falling profits and losses can be seen as a deteriorating level of competitiveness compared to other industry representatives (Bednarski, 2002; Dębski, 2005; Michalski, 2005; Tyran, 2004).

This paper presents the analysis of the economic condition of wood industry companies listed on the Warsaw Stock Exchange.

2 MATERIALS AND METHODS
2. MATERIJALI I METODE

The analysis included the representatives of the furniture industry: „A" and „B", the wood-based panel industry: „C" and „D", representatives of the pulp and paper industry: „E" and „F", the sawmill industry: „G" and „H", working in the wood-based panel and furniture industry. The main selected indicators of ratio analysis and Mączyńska & Zawadzki's polynomial were calculated. The calculations were based on data from the annual financial statements of the analyzed companies from the period 2008-2010. For the purpose of solving the decision tasks related to the optimization of output assortments, it is necessary to show separately variable costs influenced by changes in volume of production and fixed costs not influenced by changes in volume of production (Potkany, 2005).

The representative of the furniture industry - „B", founded in 1992 by Maciej Formanowicz in Ostrów Mazowiecka, was the first analyzed company. „B" is the top Polish manufacturer and exporter of furniture, owning four manufacturing facilities in Poland and ten sales companies. The company employs more than 2000 employees. The export generates about 80 % of the company sales revenues. The main product of „B" is cabinet furniture, whose sales value is over 90 % of total company sales.

The representative of the furniture industry - „A" was the second analyzed company. The company started business in 1993, and it was engaged in the production of beds for children and infants. Gradually, the production of furniture for children was expanded to include wood-based panel furniture for children rooms, such as: cabinets, dressers, bookshelves and desks. Furthermore, the company produces textiles for children. The company has been listed on the stock exchange since 2008.

Further representatives of timber industry are classified as wood-based panel companies and these are: „C" and „D".

„C" belongs to an international corporation Pfleiderer. The company includes factories in Grajewo, Wieruszów, Veliky Novgorod (Russia) and the glue factory Silekol in Kędzierzyn-Koźle. The company production includes a wide range of laminated and veneered boards, raw and laminated HDF, high-pressure laminates HPL, new on the Polish market – MFP building boards, furniture foils and adhesive resins.

„D" specializes in the production of wet-processed hardboards. The company production also includes raw hardboards, single color lacquered hardboards and hardboards lacquered in the wood structure. The company was founded in 1970. „D" entered the Warsaw Stock Exchange in 2008 and employs almost 430 people.

„E" is a pulp and paper company that was founded in 1989. The first listing of the company's shares on the stock exchange took place in 1996. „E" produces articles intended for office applications, for example: printing materials, including general forms (for example: invoices), printer paper, paper rolls used in cash registers, faxed and mobile printers.

„F" was set up in 1961 under the name of Zakłady Celulozy i Papieru in Świecie. The company's shares were listed for public trading on the Warsaw Stock Exchange in 1997. In 2008 the name of the company was changed. In 2010, the company's output was 1,313 thousand tons of corrugated and sack paper.

„G" has been engaged in wood industry for 60 years. The main company's products are: edged and unedged sawn timber, fresh, dried, planed and treated, construction elements for roofs and house constructions, glued elements, sleepers, floor boards, wainscot, skirting boards, elements for furniture production and other goods, small garden architecture. Pine, beech and oak are mostly used as raw materials. Spruce, birch, ash and hornbeam are also processed in smaller quantities.

„H" is a company dedicated to designing, manufacturing and distribution of furniture, plywood and lumber and wood-based boards trade. The commercial unit of the company is located in Warsaw. Designing and furniture manufacturing takes place in Jasienica – the headquarters of the company „H". The production of plywood takes place in plywood mills „H" in Morąg. The Group „H" includes: 3 plants producing plywood, 3 plants producing furniture, 2 foreign trade companies and 16 commercial warehouses in Poland. „H" offers a wide range of plywood, furniture and wood-based panels such as: chairs, stools, tables, plywood, veneer, joinery, HDF, MDF, OSB and others.

The basic indicators of ratio and Mączyńska & Zawadzki's polynomial analysis were used for the calculations. The calculations were based on public data from the annual financial statements of the analyzed companies listed on the Warsaw Stock Exchange in the period 2008-2010. The calculations were performed using Excel. The chosen indicators can be easily ap-

Table 1 Indicators of ratio analysis used in calculations
Tablica 1. Pokazatelji analize omjera upotrijebljenih u kalkulacijama

Number *Redni broj*	**Ratios group** *Skupina omjera*	**Ratio** / *Omjer*	**Definition** / *Definicija*
1	Profitability ratios *udjeli profitabilnosti*	return of equity – ROE *povrat kapitala*	Net profit/equity *neto dobit/kapital*
		return of assets – ROA *povrat sredstava*	Net profit/total assets *neto dobit/ukupna sredstva*
		return of sales – ROS *povrat od prodaje*	Net profit/sales revenue *neto dobit/prihod od prodaje*
2	Debt ratios *udjeli dugovanja*	debt ratio *omjer dugovanja*	Total liabilities/total assets *ukupne obveze/ukupna sredstva*
		debt to equity ratio *omjer dugovanja prema kapitalu*	Long-term liabilities + short-term liabilities/equity *dugotrajne obveze + kratkotrajne obveze/ kapital*
		long term debt ratio *omjer dugotrajnog dugovanja*	Long-term liabilities/equity *dugotrajne obveze/kapital*
3	Liquidity ratios *udjeli likvidnosti*	current ratio *trenutačni omjer*	Current assets/long-term liabilities *trenutačna sredstva/dugotrajne obveze*
		quick ratio *brzi omjer*	Current assets-supplies-prepayments/short-term liabilities / *trenutačna sredstva – ponuda – pretplaćanje/ kratkotrajne obveze*
		cash to debt ratio *omjer gotovine u dugovanju*	Cash equivalents/short-term liabilities *ekvivalenti gotovine/kratkotrajne obveze*

Source: based on Sierpińska and Jachna (2004)

plied and compared with various values of companies assets (Jerzemowska, 2004; Stępień, 2008; Stradomski, 2004). The list of indicators and their definition are shown in Table 1.

3 RESULTS AND DISCUSSION
3. REZULTATI I RASPRAVA

The results of calculation of profitability ratios for stock-listed wood processing companies are shown at Figure 1 and Figure 2.

The analysis of Figure 1 and Figure 2 shows that the best results in the field of profitability are achieved by the company „F". In the year 2010, only this company achieved positive values of all profitability indicators, namely: return of equity ratio reached 0.17; return of assets ratio and return of sale ratio both reached 0.11. This mean that the company has made from 0.11 to 0.17PLN of net profit for each 1PLN invested equity, assets or sales revenues. In contrast, the year 2010 was not good for the second representative of pulp and paper industry – „E". This company reached the highest values of profitability ratios in 2008, for example – the return of sales revenues value reached 0.17. Particularly low values of profitability ratios were achieved by the furniture industry company – „A". This situation can be explained by the increasing financial losses. For wood-based board companies, such as „C" and „D", the year 2010 was the weakest year in terms of values of profitability ratios. This means that the economic crisis was not avoided by companies in woodworking industry.

Debt ratios were the second group of the calculated ratio indicators. The results of calculations are illustrated in Figure 3 and Figure 4.

The analysis of Figure 3 and Figure 4 shows that the worst values of debt ratios are achieved by „H",

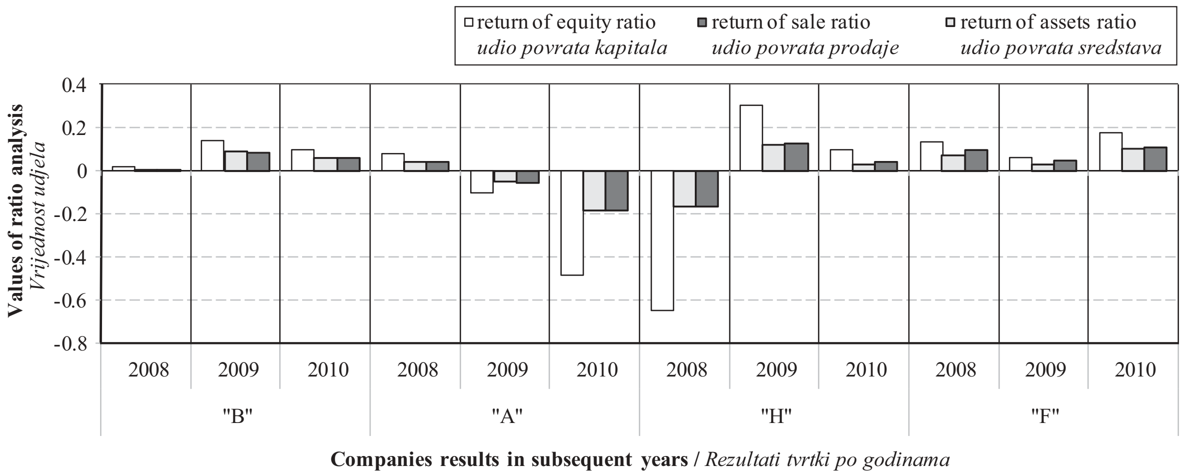

Figure 1 Results of analysis of the selected profitability ratios of wood sector companies „B", „A", „H", „F" listed on Warsaw Stock Exchange
Slika 1. Rezultati analize odabranih omjera profitabilnosti za „B", „A", „H", „F" tvrtke drvnog sektora na Varšavskoj burzi

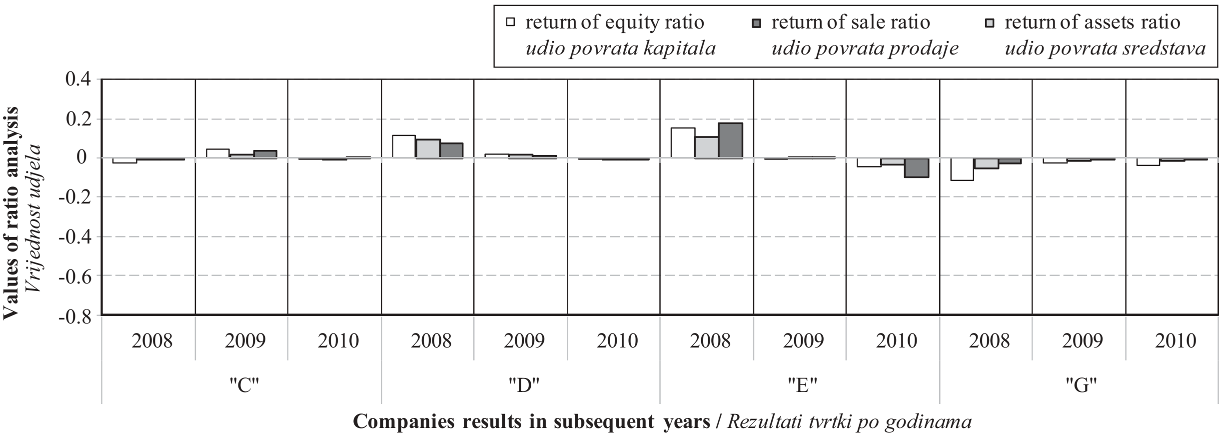

Figure 2 Results of analysis of the selected profitability ratios of wood sector companies „C", „D", „E", „G" listed on Warsaw Stock Exchange
Slika 2. Rezultati analize odabranih omjera profitabilnosti za „C", „D", „E", „G" tvrtke drvnog sektora na Varšavskoj burzi

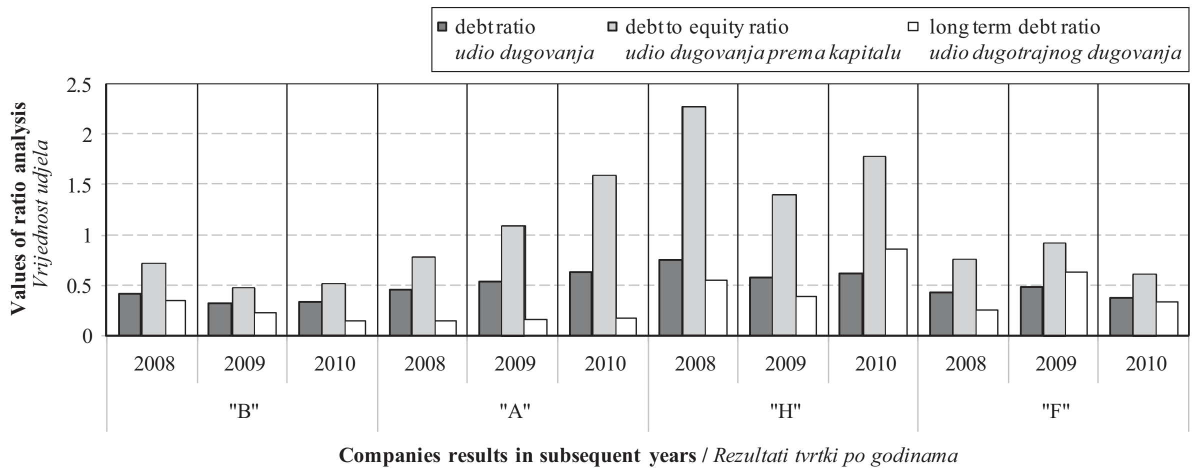

Figure 3 Results of analysis of the selected debt ratio of wood sector companies „B", „A", „H", „F" listed on Warsaw Stock Exchange
Slika 3. Rezultati analize odabranih omjera dugovanja za „B", „A", „H", „F" tvrtke drvnog sektora na Varšavskoj burzi

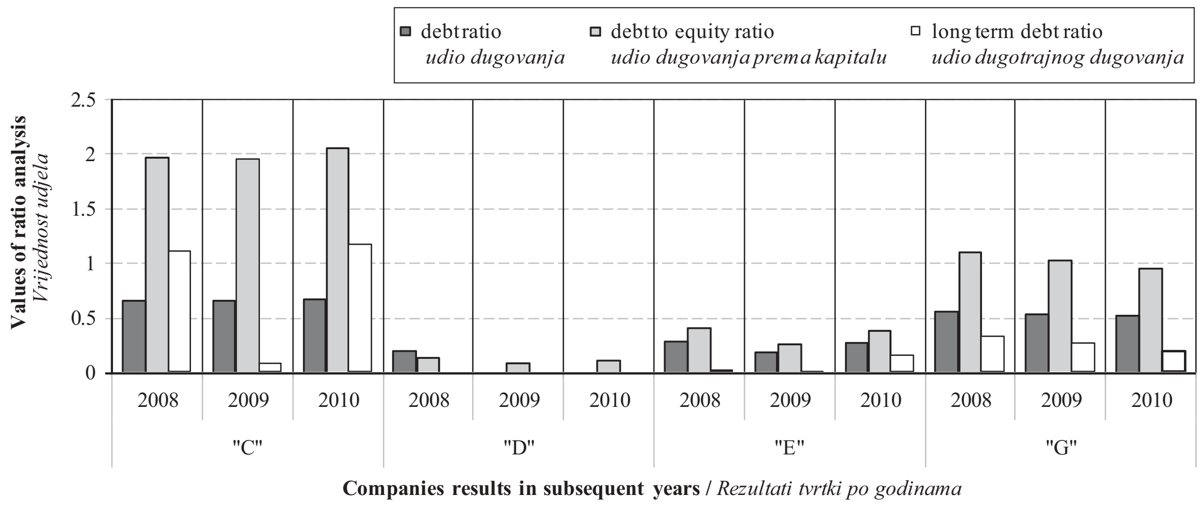

Figure 4 Results of selected debt ratio analysis of „C", „D", „E", „G" wood sector companies listed on Warsaw Stock Exchange
Slika 4. Rezultati analize odabranih omjera dugovanja za „C", „D", „E", „G" tvrtke drvnog sektora na Varšavskoj burzi

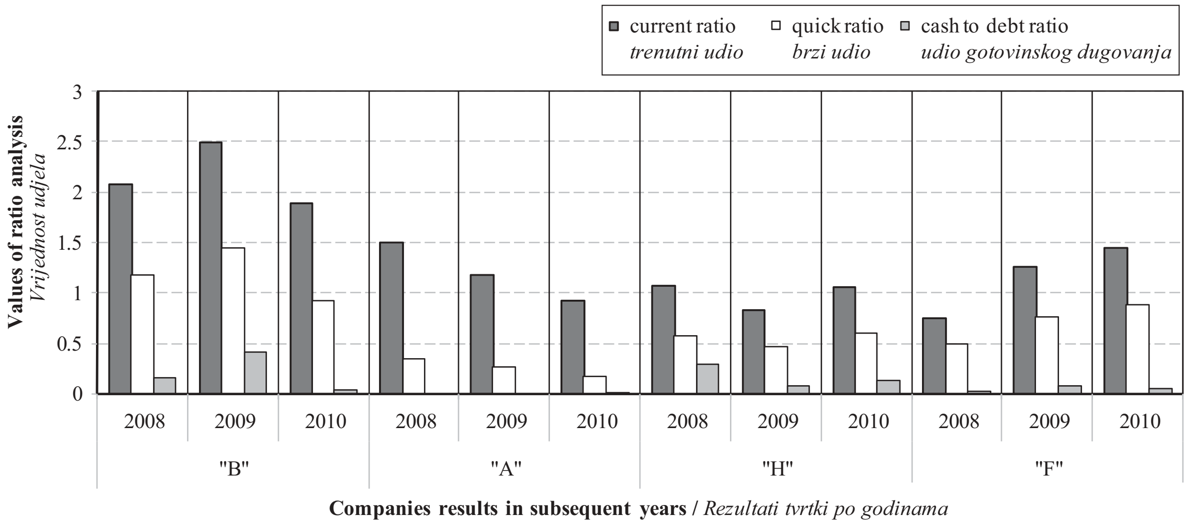

Figure 5 Results of analysis of the main liquidity ratios of wood sector companies „B", „A", „H", „F" listed on Warsaw Stock Exchange
Slika 5. Rezultati analize omjera osnovne likvidnosti za „B", „A", „H", „F" tvrtke drvnog sektora na Varšavskoj burzi

„C" and „A". These companies achieved especially high values for debt to equity ratios. For example, debt to equity ratio values for „H" ranged between 2.29 in 2008 and 1.41 in 2009. The year 2010 was worse for the company than the year 2009 – the value of debt to equity ratio increased to 1.78. The values of debt to equity ratios indicate that the total liabilities are almost twice the value of the equity. The lowest values of debt ratios were achieved by „D", „E" and „B". The equity is covered by liabilities in a small extent for „D" (from 9 to 14 %) and for „E" (from 26 to 41 %) while for „B" it reaches 48 – 72 %.

Liquidity ratios are the last group of indicators calculated in this paper. The results of liquidity ratio analysis are shown in Figure 5 and Figure 6.

As shown by the analysis of Figure 5 and Figure 6, the current assets cover the long-term liabilities to the highest degree in companies „B" and „D". Current ratio values for „B" are the highest in the years 2008 and 2009 (2.08 and 2.50, respectively) and for „D" in the years 2009 and 2010 (3.97 and 5.55, respectively). The lowest values of current ratio are observed for „C" – in subsequent years of analysis the company reached: 0.20 in 2008; 0.20 in 2009 and 0.43 in 2010, respectively.

The highest values of a more critical indicator, namely quick ratio, were also observed for companies „D" and „B". The current assets without supplies have covered short-term liabilities of „D" more than 2 or even 3 times, in „B" they covered short-term liabilities about 100 %. The sawmill company „G" shows very good results of liquidity ratios and „F" shows increasing values.

Ratio analysis provides a specific range of information to a researcher. Therefore, early warning bankruptcy models are often used to provide a general insight into the economic condition of a company. Most early warning methods, also called discriminant models, are based on a polynomial structure using the combination of some independent variables and their assigned

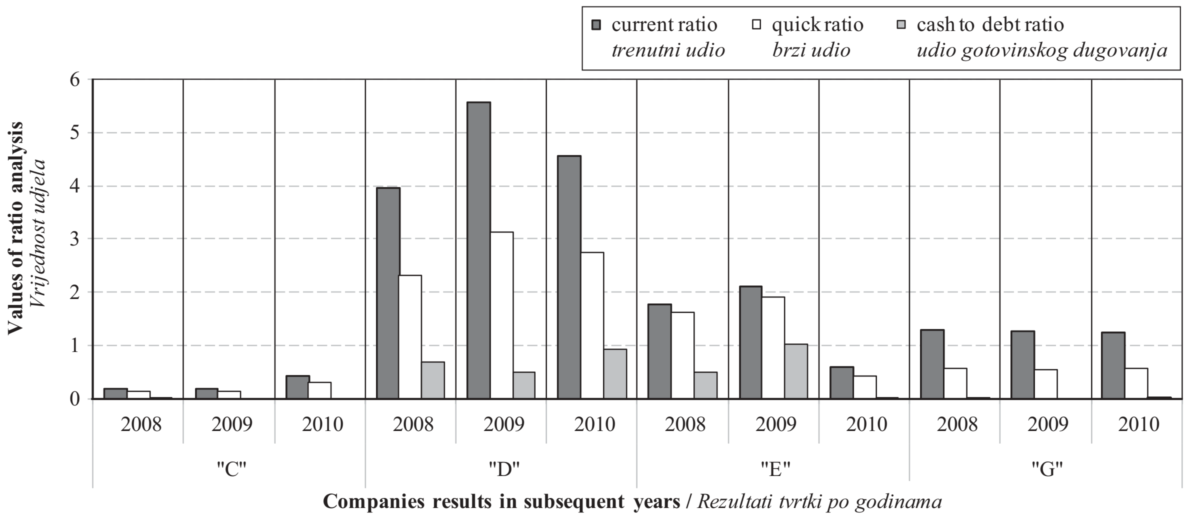

Figure 6 Results of analysis of the main liquidity ratios of wood sector companies „C", „D", „E", „G" listed on Warsaw Stock Exchange
Slika 6. Rezultati analize omjera osnovne likvidnosti za „C", „D", „E", „G" tvrtke drvnog sektora na Varšavskoj burzi

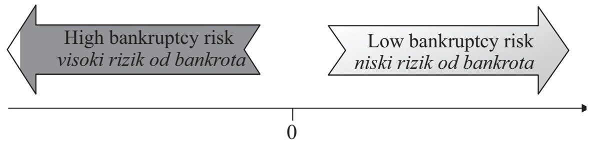

Figure 7 Companies classification in Mączyńska & Zawadzki's method
Slika 7. Klasifikacija tvrtki prema metodi Maczynska & Zawadzki

weights. This function structure allows qualifying the analyzed companies into two or more groups, usually:
a) group without bankruptcy risk,
b) group with bankruptcy risk or
c) group with an uncertain bankruptcy risk (Nowak, 2005).

The Mączyńska & Zawadzki's model qualifies companies into two groups, as shown in Figure 7.

The Mączyńska & Zawadzki's model is composed of four variables and it is calculated as follows:

$$Z_{MZ} = 9.498 \cdot x_1 + 3.566 \cdot x_2 + 2.903 \cdot x_3 + 0.452 \cdot x_4 - 1.498,$$

whereas:
Z_{MZ} – score of Mączyńska & Zawadzki's polynomial;
$x_1 - x_4$ = discriminant variables:
x_1 = net operating profit/assets;
x_2 = equity/assets;
x_3 = (net profit + amortization)/total liabilities;
x_4 = current assets/short-term liabilities (Gołębiowski and Tłaczała, 2009)

Figure 8 shows all wood sector companies listed on the Warsaw Stock Exchange as a result of Mączyńska & Zawadzki's method analysis.

As shown in Figure 8, the lowest values of Mączyńska & Zawadzki's polynomial were observed for „C". The company achieved the best results in 2008 and they reached 0.521. Decreased values of Mączyńska & Zawadzki's method can prove weakening of economic conditions of a company. Also, the lowest value of this method was observed for „H" in 2008. In the second year of analysis, the company achieved a higher value, namely 2.713. Unfortunately, the world economic crisis affects the company results and this value has decreased to 0.837. Quite good results of Z_{MZ} function was reached by „G". Throughout the analyzed period, company results stay on a similar level ranging from 0.913 in 2008 to 1.513 in 2010. The results of „B" are quite good, too. The best values of Mączyńska & Zawadzki's polynomial were reached in the year 2010 by representatives of the pulp and paper industry – „E" and „F". This could be achieved thanks to a good economic situation of these companies. Decreasing values of Mączyńska & Zawadzki's method of „B", „A", „D", „E" and „H" can be alarming. These figures may indicate deteriorating competitiveness position of the mentioned companies.

4 CONCLUSION
4. ZAKLJUČAK

The results of the analysis showed that the crisis in the global market affected the wood industry sector. As shown by EUROSTAT data, wood and wood industry companies, excluding furniture sector companies, reached in Poland in 2008 the number of about 20,000. In subsequent years, the number of these companies has decreased by about 17 %. In the same period, the amount of veneer sheet and wood-based panel enterprises has decreased by about 9 %. The number of furniture companies has increased by about 36 % and the number of paper and paper products companies has increased by more than 22 % in the same period. The increasing number of entities is not always followed by increasing production values. For example, in 2009 furniture production value has decreased by almost 13 % compared to the previous year, sawmilling and planning of wood production value by 30 %, veneer and wood-based panels by 25 % and paper and paper products by 14 %.

KUKE SA (Export Credit Insurance Corporation Joint Stock Company) analysis shows that since 2008, the number of failing companies has increased: in 2010 668 companies went bankrupt and in 2011, as a result of insolvency, 743 entities went bankrupt.

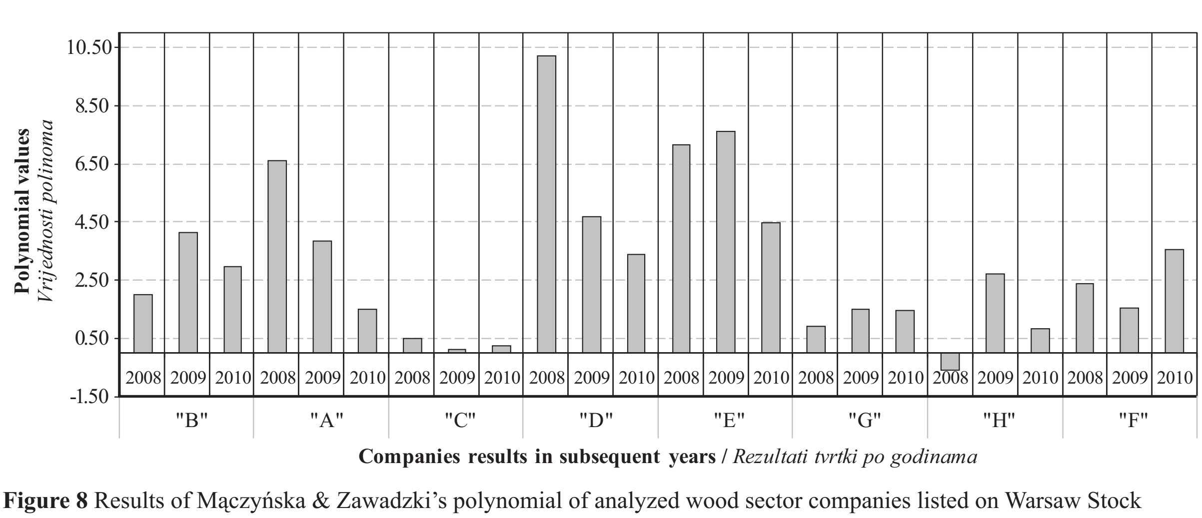

Figure 8 Results of Mączyńska & Zawadzki's polynomial of analyzed wood sector companies listed on Warsaw Stock Exchange
Slika 8. Rezultati Maczynska & Zawadzki polinoma analiziranih tvrtki drvnog sektora na Varšavskoj burzi

As a result of increasing difficulties in the market, companies had to cut costs. For example, in furniture companies salaries dropped by 19 % in 2009 compared to the previous year. In other sectors salaries dropped, too: in sawmilling industry by about 25 %, in veneer and wood-based panel companies by about 27 %, in paper and paper products companies by about 14 %. The National Bank of Poland reports that the companies gathered at the end of 2011 at the bank accounts approximately PLN 200 billion. Considering the difficult market situation, companies warned that they would not hire new employees nor invest. This in turn could affect negatively their competitive position, but on the other hand, could help them preserve the ability to pay.

Acknowledgement - Zahvala

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Šumarski fakultet Sveučilišta u Zagrebu

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organizira i poziva Vas na

23. MEĐUNARODNO ZNANSTVENO SAVJETOVANJE

"DRVO JE PRVO – ZNANJEM I TEHNOLOGIJOM DO KONKURENTNOSTI SEKTORA ŠUMARSTVA I PRERADE DRVA"

12. listopada 2012. godine, Zagrebački velesajam

Poštovani,

Naše tradicionalno savjetovanje u okviru 39. međunarodnog sajma namještaja, unutarnjeg uređenja i prateće industrije održat će se **12. listopada 2012.** na Zagrebačkom velesajmu. Tema ovogodišnjeg savjetovanja je "DRVO JE PRVO – znanjem i tehnologijom do konkurentnosti sektora šumarstva i prerade drva".

Pozivamo Vas da nam se pridružite.

Predsjednik
Znanstvenog odbora
Savjetovanja AMBIENTA '12
prof. dr. sc. Ivica Grbac

Koordinator
projekta Znanstvenog
savjetovanja AMBIENTA '12
doc. dr. sc. Goran Mihulja

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Wood Sector Media Promotion in Some South-East European Countries

Medijska promocija drvnog sektora u nekim zemljama jugoistočne Europe

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ABSTRACT • *Wood processing and furniture manufacturing is one of the key industrial sectors in South-East European countries. Based on its share in GDP, this industrial sector should be part of the national strategy plans. However, media coverage of wood processing and furniture manufacturing in Croatia, as well as in other South-East European countries, is far behind the promotion of other industrial sectors. This paper presents the current situation in promotional activities of wood sector in some South-East European countries media and it shows the differences between individual countries. Also, it presents some ideas on improving this situation according to media share of other highly profiled industrial sectors in some South-East European countries.*

Key words: *wood sector, media, media coverage, insertations, promotion investments*

SAŽETAK • *Prerada drva i proizvodnja namještaja pripada važnijim industrijskim granama u zemljama jugoistočne Europe. Njezin udio u bruto nacionalnom dohotku svrstava tu industrijsku granu među one koje bi trebale naći svoje mjesto u nacionalnim strateškim planovima. Međutim, medijsko praćenje prerade drva i proizvodnje namještaja u Hrvatskoj, kao i u drugim zemljama jugoistočne Europe, daleko zaostaje za promocijom nekih drugih industrijskih i ekonomskih grana i sektora. Ovaj će članak prikazati trenutačnu situaciju u promotivnim aktivnostima drvnog sektora u medijima nekih zemalja jugoistočne Europe i istaknuti postojeće razlike među pojedinim zemljama. Usto će dati neke ideje kako popraviti postojeću situaciju u drvnom sektoru u odnosu prema drugim, promotivno visoko pozicioniranim industrijskim granama u pojedinim zemljama jugoistočne Europe.*

Ključne riječi: *drvni sektor, mediji, medijska pokrivenost, insertacije, investicije u promociju*

1 INTRODUCTION
1. UVOD

When selecting the countries to be involved in this research, we chose 3 countries in South-East European region with a similar level of wood processing and furniture manufacturing in state economy. It was also decided to include countries of different status with respect to the European Union. Therefore Croatia, Slovenia and Serbia were included in this research. As all these countries have a very similar way of investigating media coverage of particular industrial and eco-

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nomic sectors within their countries, they could be easily compared.

The Republic of Croatia is located in South-East Europe with a total area of more than 56 thousand km^2 and with the population of 4.5 mil people. In Croatia wood represents a significant raw material. The share of wood processing and furniture manufacturing in the Croatian GDP was about 2 % in 2007. The annual wood consumption in Croatia is more than 3.4 mil m^3 and in the year 2007, the revenues were over 1 billion Euros with more than 25 thousand employees. (Source: Statistical Yearbook of Croatia)

Industrial production indexes show significant decrease from 2007 to 2010. The same goes for wood processing and furniture manufacturing, since these industrial sectors are the first to respond to any crisis, especially a global one. The main reason for this is the fact that wood processing and furniture manufacturing in Croatia are highly export-oriented. So, any disturbances in the global or European market have a significant influence on Croatian wood processing and furniture manufacturing (Jelačić, 2010).

The situation with employment is almost the same. The total number of employees in wood processing and furniture manufacturing decreased from 25,000 in 2007 (which was 9.8 % of all employees in the industrial sector, and 1.67 % of all employees in Croatia) to 21,000 in 2009 (9 % in the industrial sector, i.e. 1.41 % of all employees). (Source: Statistical Yearbook of Croatia).

Economic recession has strongly influenced the operation of companies in the last several years. Its influence can be seen in all business fields, and hence also in the promotion activities of wood processing and furniture companies. At the moment, Croatia is in the process of ratification of agreement and preparing to become part of the European Union in 2013.

The Republic of Slovenia is located west of Croatia with a total area of more than 20 thousand km^2 and with the population of 2 mil people. The share of wood processing and furniture manufacturing in the Slovenian GDP was about 1.5 % in 2007. In the year 2007, the revenues were over 1.5 billion Euros with more than 22.5 thousand employees.

Industrial production indexes also show significant decrease from 2007 to 2010. The total revenues decreased from 1.5 billion Euros in 2007 to 0.75 billion Euros. The total number of employees in wood processing and furniture manufacturing decreased from 22,500 in 2007 to 17.000 in 2010 and to 15,500 in 2011. Slovenia is a member of the European Union. (Source: Statistical Yearbook of Slovenia).

The Republic of Serbia is located east of Croatia with a total area of 88 thousand km^2 and with the population of 7.2 mil people. The global economic crisis affected badly wood processing and furniture manufacturing in Serbia, so the number of employed people in that industrial sector decreased to 29,300 in 2010, which was 1.63 % of all employed persons in Serbia. Serbia has just started the negotiation process with the European Union. (Source: University of Belgrade, Faculty of Forestry, Center for Marketing and Economics of Wood Industry).

2 MATERIAL AND METHODS
2. MATERIJAL I METODE

According to EFFIE index, 400 billion USD per year is spent on advertising and promotional activities in the world. That amount is increasing each year by 5 % at least (Žujo, 2011).

Large amount of that money is invested into advertising and promotional activities on TV and printed media (newspapers, journals, magazines, etc.) (Stasiak-Betlejewska and Borkowski, 2007).

In South-East Europe most of the adverts appear on TV, radio and in printed media, although other ways of promotion, such as billboards or brochures and flyers, cover a significant share of the market. At the moment, the most successful promotions are those that cover several different ways of marketing, including social networks, such as Facebook (Žujo, 2011).

This paper focuses on promotional activities on TV and in printed media monitored by official agencies for monitoring the promotion in the key media in Croatia, Slovenia and Serbia.

AGB Nielsen is the agency that monitors insertations of adverts on national TV channels (6 national TV channels) and Gross Rating Point (GRP) index of these TV channels. Insertation is the number of broadcastings of a particular advert on a TV channel.

IPSOS is the agency that monitors adverts in printed media and on the radio. Since they have just started monitoring radio stations, the data only covers printed media. The available data will be presented through financial investments in promotion in different printed media.

The research period was from 2006 to 2011, and it covered the years of good economic conditions, the years of global recession and the years of new growth and development after the crisis.

To compare the share of the total number of insertations and the share of the total investments in promotion among Croatia, Slovenia and Serbia, the *Analysis of Variance* was used, popularly known as the ANOVA test. When using the ANOVA procedure, it is assumed that the data from each group follow a normal distribution and that the groups to be compared have homogeneous variances. If the variances are not all equal, the Kruskal-Wallis test (the nonparametric equivalent of the ANOVA test) should be used. Tukey HSD post hoc test was used to determine the significant difference, if any, in the ANOVA (Troendle, 1995). All analyzes were performed using the statistical package Statistics 7.1 (StatSoft Inc., 2006).

3 RESEARCH RESULTS
3. REZULTATI ISTRAŽIVANJA

Insertation is the number that shows how many times certain advert or group of adverts from a certain sector was broadcasted on a national TV channels.

Table 1 Total number of TV insertations in individual countries for the period 2006-2010
Tablica 1. Ukupni broj emitiranja na TV-u u pojedinoj zemlji u razdoblju 2006-2010.

Country / *Država*	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Croatia / *Hrvatska*	242 843	277 126	336 999	301 928	342 407	440 357
Slovenia / *Slovenija*	369 338	375 098	441 295	471 661	645 432	642 589
Serbia / *Srbija*	606 482	823 373	882 507	955 407	1 111 448	1 440 619

Table 1 shows the total number of insertations for the period 2006-2011 in Croatia, Slovenia and Serbia.

As shown in Table 1, the total number of insertations in Slovenia and Serbia show constant growth year after year, while in Croatia the total number of insertations decreased in the year after the financial crisis started in Croatia. Afterwards, it showed growth again. It is interesting to observe that the total number of insertations in Croatia is much less than in Slovenia, and even the Total Individual Universe (number of viewers) in Croatia is more than twice the Total Individual Universe in Slovenia (4.161.532 spectators in Croatia and 1.927.657 spectators in Slovenia). It is even more interesting since the number of national TV channels included in the research was 6 in Croatia, 5 in Slovenia and 19 in Serbia.

Table 2 presents the share of the furniture, household appliances and household accessories sector in the total number of insertations.

As shown above, the share of furniture TV promotion is much higher in Serbia than in Croatia and Slovenia. However, these shares have different trends in individual countries. In Croatia, this share was growing until 2008, then it was decreasing until 2010, and in 2007 and 2011 it was almost the same. In Slovenia, it rapidly decreased in 2008, it starting growing again in 2010 and in 2011 it was at the level of 0.29 %. In Serbia, it was constantly decreasing and dropped from 1.60 % in 2007 to 0.67 % in 2011.

The following figures show the share of several sectors most often advertised on TV and of furniture, household appliances and accessories sector (Figures 1 to 3), and then of furniture sector in particular (Figures 5 to 7).

According to Figure 4, Kruskal-Wallis test shows that there is a significant difference between the total number of insertations and that the difference is caused by data from Serbia.

Table 2 and Figures 1 to 3 clearly show that the sector of furniture, household appliances and accessories did not have the position it deserved on TV channels. This especially applies to Croatia and Slovenia, since the share of this sector in TV promotion was from 0.20 % in Slovenia for 2009 to 0.74 % in Croatia for the same year. The situation in Serbia is a little bit better, since the share of furniture, household appliances

Table 2 Share of furniture, household appliances and household accessories sector in TV promotion for individual countries in the period 2006-2011 (in %)
Tablica 2. Udio sektora namještaja, kućnih uređaja i opreme u TV promociji za pojedinu zemlju u razdoblju 2006-2011. (u %)

Country / *Država*	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Croatia / *Hrvatska*	0.57	0.51	0.65	0.74	0.46	0.50
Slovenia / S*lovenija*	0.43	0.53	0.25	0.20	0.30	0.29
Serbia / *Srbija*	1.59	1.60	1.63	1.06	1.09	0.67

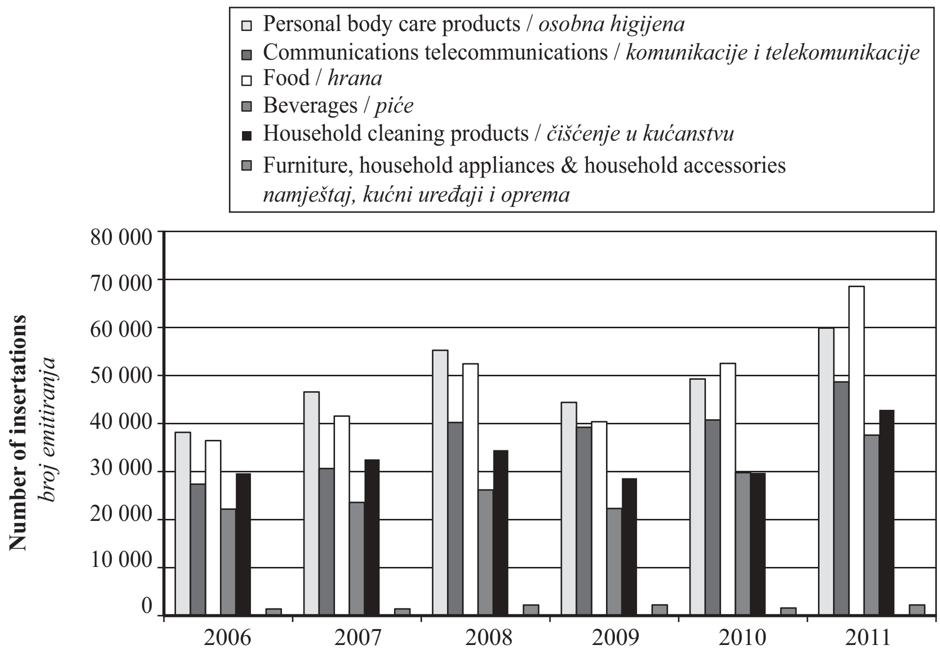


Figure 1 Number of insertations for specific sectors in Croatia for the period 2006-2011
Slika 1. Broj emitiranja za pojedine sektore u Hrvatskoj u razdoblju 2006-2011.

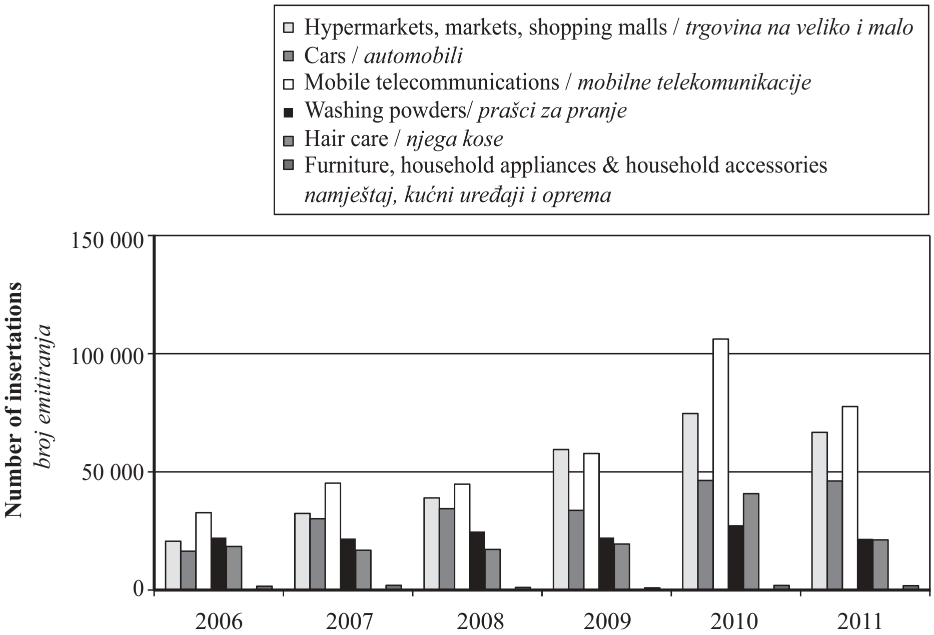


Figure 2 Number of insertations for specific sectors in Slovenia for the period 2006-2011
Slika 2. Broj emitiranja za pojedine sektore u Sloveniji u razdoblju 2006-2011.

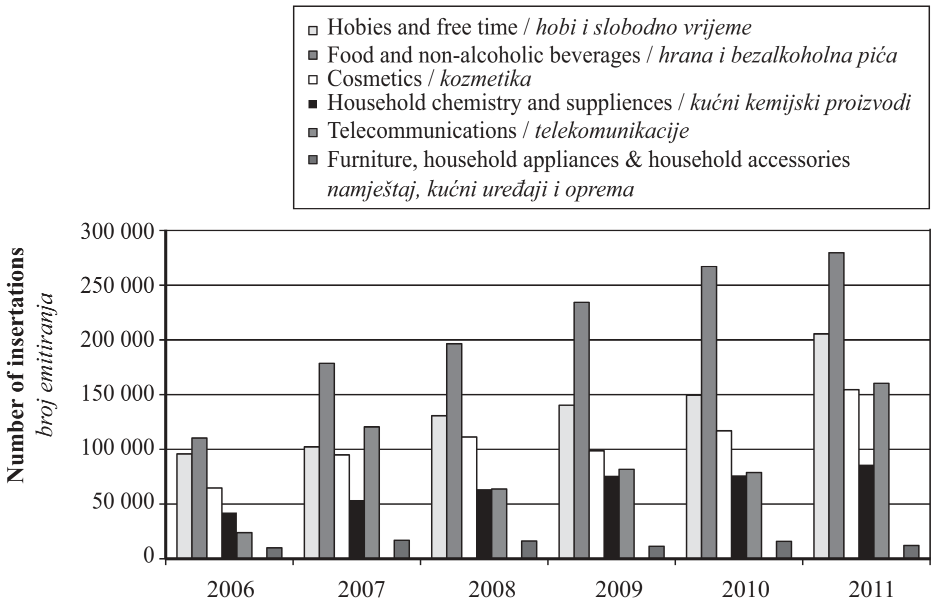


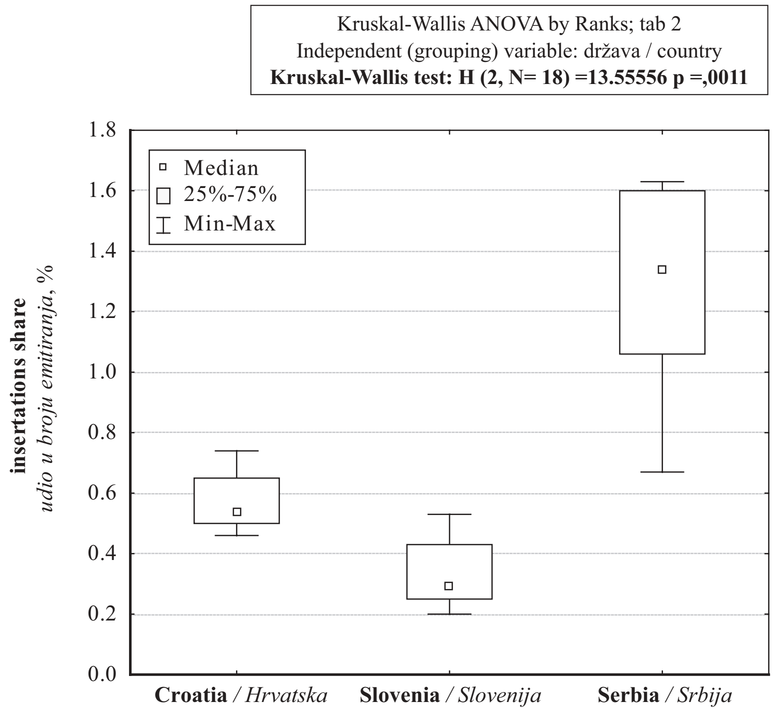
Figure 3 Number of insertations for specific sectors in Serbia for the period 2006-2011
Slika 3. Broj emitiranja za pojedine sektore u Srbiji u razdoblju 2006-2011

and accessories sector was 0.67 % for 2011 to 1.63 for 2008. However, this share is almost constant with small variations in Croatia and Slovenia, while in Serbia it is decreasing significantly every year.

The position of furniture within the furniture, household appliances and accessories sector is much better in Croatia and Serbia than in Slovenia, since in Croatia the share of furniture itself within the sector is between 50.14 % (2011) and (84.75 % (2011), and in Serbia it is between 36.07 (2008) and 73.20 (2010), while the share of furniture within the sector in Slovenia is very low and it ranged between 4.41 % (2011) and 13.92 % (2006). As shown in Figures 4 to 6, furniture, household appliances and accessories sector consists of different groups in different countries, but it can be compared when rearranged.

Printed media promotion activities are monitored by IPSOS but not based the number of adverts in all Croatian, Slovenian or Serbian printed media, but based on money invested in printed media advertising according to the applicable price list in a particular newspaper or magazine.

Advertising is not monitored by sectors, e.g. on TV, but according to groups of products or production programs. Therefore, the printed media data differs from TV data, but nevertheless the state of promotion activities of wood processing and furniture manufacturing sector can be observed in three countries in question. The following figures show the share of financial investments in printed media promotion by wood processing and furniture manufacturing and the share of some other commonly advertized sectors for comparison.



Multiple Comparisons p values (2-tailed); Tab. 2 (Spreadsheet49) Independent (grouping) variable: country / *država* Kruskal-Wallis test: H (2, N= 18) =13,55556 p =,0011			
	Croatia / *Hrvatska*	**Slovenia** / *Slovenija*	**Serbia** / *Srbija*
Croatia / *Hrvatska*		0.281045	0.136264
Slovenia / *Slovenija*	0.281045		0.000708
Serbia / *Srbija*	0.136264	0.000708	

Figure 4 Comparison of shares of the total number of insertations between Croatia, Slovenia and Serbia
Slika 4. Usporedba ukupnog broja emitiranja u Hrvatskoj, Sloveniji i Srbiji

Table 3 Share of furniture within furniture, household appliances and household accessories sector for specific countries in the period 2006-2011 (in %)
Tablica 3. Udio namještaja u sektoru namještaja, kućnih uređaja i opreme za pojedinu zemlju u razdoblju 2006-2011 (u %)

Country / Država	2006	2007	2008	2009	2010	2011
Croatia / *Hrvatska*	67.58	61.41	78.18	84.75	67.94	50.14
Slovenia / *Slovenija*	13.92	13.76	4.74	12.97	8.85	4.41
Serbia / *Srbija*	62.69	40.75	36.07	62.59	73.20	59.47

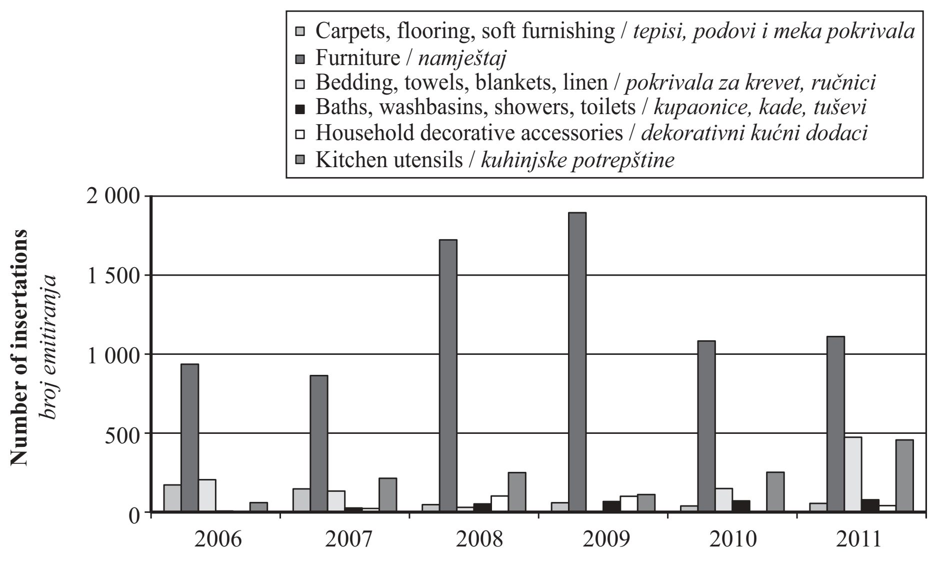


Figure 5 Number of insertations for furniture, household appliances and accessories sector in Croatia for the period 2006-2011
Slika 5. Broj emitiranja u sektoru namještaja, kućnih uređaja i opreme u Hrvatskoj u razdoblju 2006-2011.

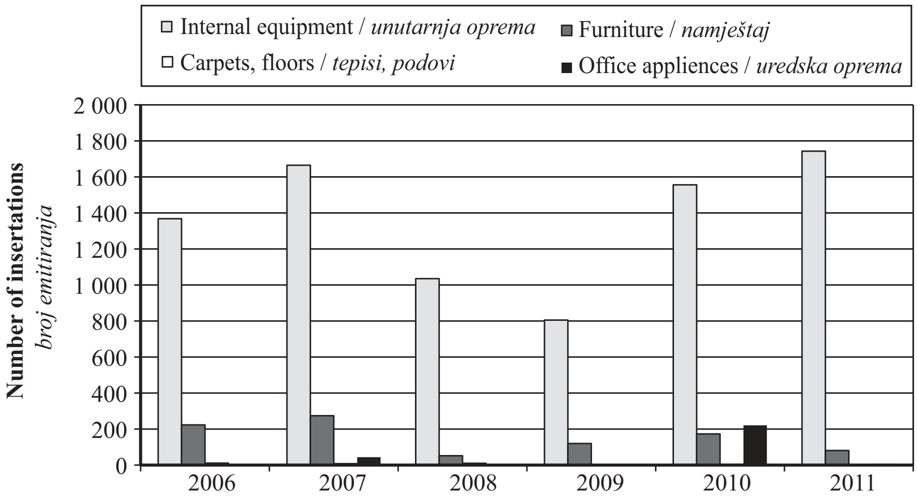


Figure 6 Number of insertations for furniture, household appliances and accessories sector in Slovenia for the period 2006-2011
Slika 6. Broj emitiranja u sektoru namještaja, kućnih uređaja i opreme u Sloveniji u razdoblju 2006-2011.

Figure 11 and Post Hoc test (Tukey HSD test) clearly show that there is a significant difference among investments in printed media promotion in all three countries.

As it can be observed from Figures 8 to 10 and Table 4, the share of furniture manufacturing in the total investment in printed media promotion is much higher than the share of promotion on TV channels. For example, in Croatia, the share of promotion on TV channels was only 0.252 % for furniture and 0.503 % for the sector of furniture, household appliances and household accessories in 2011 (the smallest). The same share of promotion on TV channels was 0.628 % for furniture and 0.741 % for the whole sector in the year 2009 (the highest). At the same time, the share of furniture adverts in printed media was 1.129 % and 1.765 % for the whole sector in the year 2011 (the smallest), which is much higher than TV promotion. Furniture achieved the highest share in the year 2006 and it was 1.803 %, and this share for the whole wood processing and furniture manufacturing sector was 2.825 %.

A similar situation has been found in Serbia, where the share of furniture in printed media promotion is higher than in Croatia and it is between 2.50 % in 2011 and 3.28 % in 2009.

In Slovenia, the situation and the share of furniture in printed media promotion is similar to the situation on TV channels. The share of furniture in printed media is between 0.28 % in 2011 and 0.67 % in 2010, and this share is higher than the share on TV channels. As shown, the share of furniture in Slovenia is much lower than shares in Croatia and Serbia.

In terms of total values, Croatian companies invest in printed media promotion much more than companies in Serbia or Slovenia. This could be expected when comparing Croatia and Slovenia, since there are

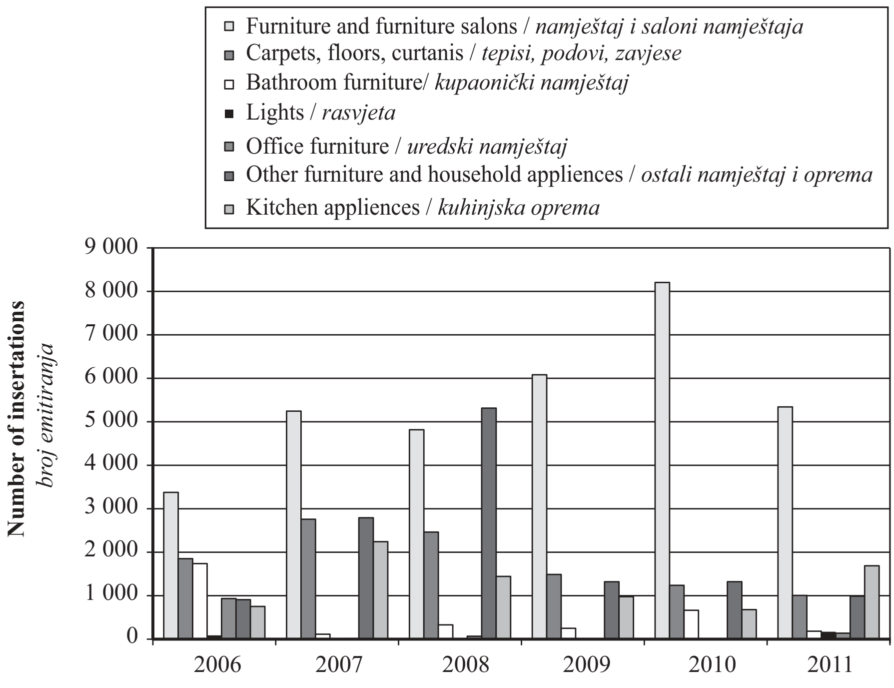


Figure 7 Number of insertations for furniture, household appliances and accessories sector in Serbia for the period 2006-2011
Slika 7. Broj emitiranja u sektoru namještaja, kućnih uređaja i opreme u Srbiji u razdoblju 2006-2011.

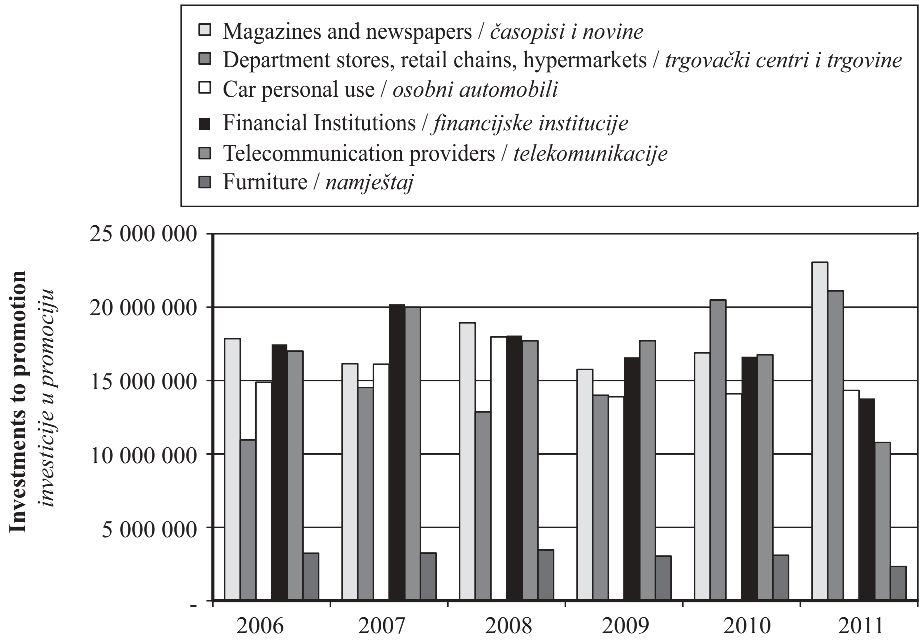


Figure 8 Investments in printed media promotion in Croatia for the period 2006-2011 (in €)
Slika 8. Investicije u promociju u tiskanim medijima u Hrvatskoj u razdoblju 2006-2011. (u EUR)

Table 4 Total investment in printed media promotion (in mil. €) and share of furniture (in %) for the period 2006-2011
Tablica 4. Ukupne investicije u promociju u tiskanim medijima (u mil. EUR) i udio izdataka u promociju namještaja (u %) u razdoblju 2006-2011.

Country *Država*	**2006**		**2007**		**2008**		**2009**		**2010**		**2011**	
	Total investment *Ukupno investirano*	Share of furniture *Udio namještaja*	Total investment / *Ukupno investirano*	Share of furniture *Udio namještaja*	Total investment *Ukupno investirano*	Share of furniture *Udio namještaja*	Total investment *Ukupno investirano*	Share of furniture *Udio namještaja*	Total investment *Ukupno investirano*	Share of furniture *Udio namještaja*	Total investment *Ukupno investirano*	Share of furniture *Udio namještaja*
Croatia *Hrvatska*	179.6	1.80	204.6	1.59	216.8	1.60	194.8	1.56	204.6	1.52	206.7	1.13
Slovenia *Slovenija*	124.5	0.47	144.3	0.47	157.8	0.40	145.3	0.64	150.8	0.67	147.2	0.28
Serbia *Srbija*	63.6	2.94	98.6	2.57	96.2	2.70	72.6	3.28	71.0	2.52	68.0	2.50

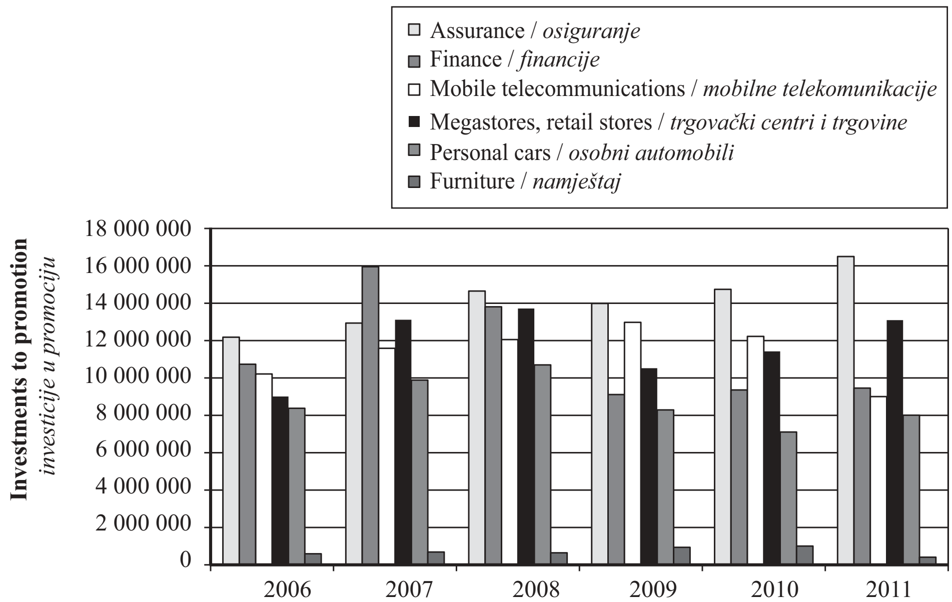


Figure 9 Investments in printed media promotion in Slovenia for the period 2006-2011 (in €)
Slika 9. Investicije u promociju u tiskanim medijima u Sloveniji u razdoblju 2006-2011 (u EUR)

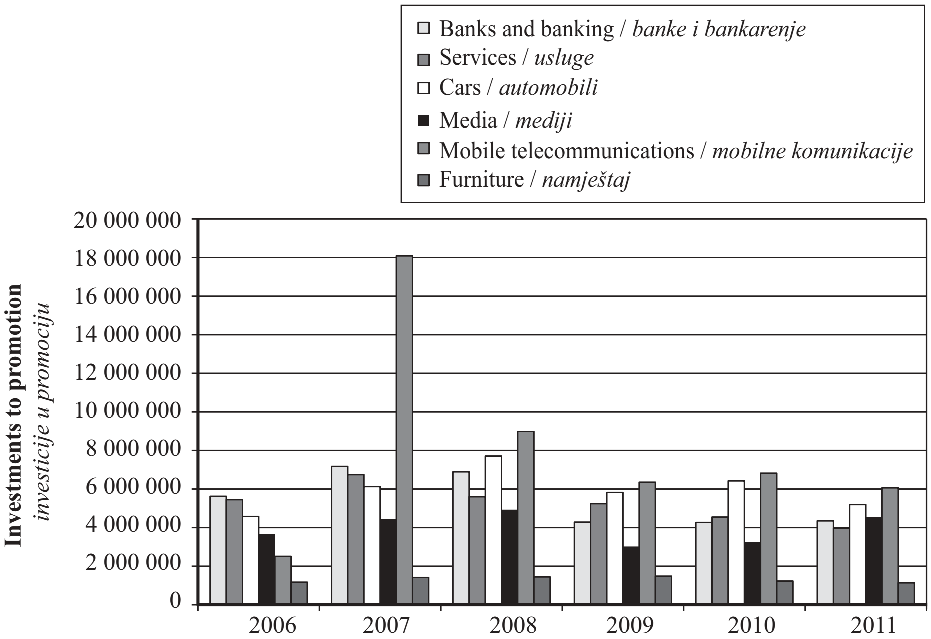
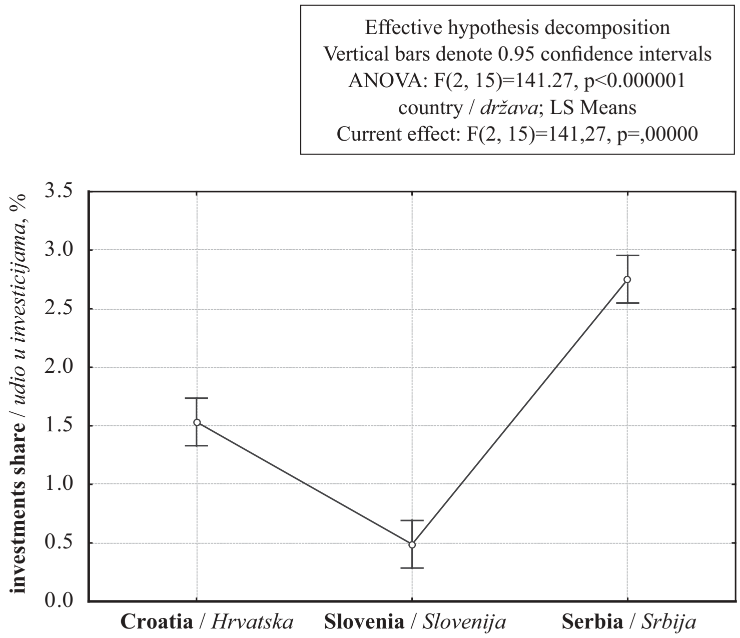


Figure 10 Investments in printed media promotion in Serbia for the period 2006-2011 (in €)
Slika 10. Investicije u promociju u tiskanim medijima u Srbiji u razdoblju 2006-2011. (u EUR)



Levene's Test for Homogeneity of Variances (Spreadsheet49) Effect: country Degrees of freedom for all F's: 2, 15				
	MS	***MS***	***F***	***p***
tab 4	0.027099	0.019019	1.424862	0.271299

Tukey HSD test; variable tab 4 (Spreadsheet49) Approximate Probabilities for Post Hoc Tests Error: Between MS = ,05450, df = 15,000				
	Country / *Država*	**Croatia** / *Hrvatska*	**Slovenia** / *Slovenija*	**Serbia** / *Srbija*
1	**Croatia** / *Hrvatska*		0.000179	0.000178
2	**Slovenia** / *Slovenija*	0.000179		0.000178
3	**Serbia** / *Srbija*	0.000178	0.000178	

Figure 11 Comparison of the share of furniture in the total investments in printed media promotion between Croatia, Slovenia and Serbia
Slika 11. Usporedba udjela troškova za promociju namještaja u ukupnim investicijama u promociju u tiskanim medijima u Hrvatskoj, Sloveniji i Srbiji

more printed publications in Croatia than in Slovenia per capita. The difference between Croatia and Serbia in the total investments in printed media promotion could partly be explained by much lower prices in € for adverts in Serbia, as there should be much more printed publications per capita in Serbia than in Croatia.

4 CONCLUSION
4. ZAKLJUČAK

The industrial sector, such as wood processing and furniture manufacturing, obviously deserves a better place in the promotion business of Croatia and Slovenia. This applies especially to TV channels, since there is a saying "if it is not on TV, it doesn't exist". According to the share of wood processing and furniture manufacturing in national GDPs in the countries concerned (2 % in Croatia, 1.5 % in Slovenia), the share of this sector in TV promotion (0.5 % in Croatia, 0.3 % in Slovenia, 0.6 % in Serbia) is not satisfactory.

The main problem for the promotion of wood products in the Croatian media is the lack of working capital, so wood processing and furniture manufacturing companies decide to invest into something else instead of promotion activities. Another reason is that there is no lobby that would promote wood processing and furniture manufacturing as an environmentally friendly industry. Wooden clusters could and should improve this situation acting jointly in that direction. The battle between wooden clusters and PVC lobby regarding joinery (windows especially) is very hard and PVC is currently winning. However, this should be changed as soon as possible. Another way for companies to improve this situation is to join in a cluster based on production program and not regionally, so as to act together in promotion activities. This would be especially useful with respect to TV promotion, since it is much more expensive than printed media promotion.

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Quality of Corner Joints of Beech Chairs under Load

Kvaliteta kutnog spoja bukovih stolica pri opterećenju

Original scientific paper • Izvorni znanstveni rad
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*UDK: 630*812.7; 630*824.1; 674.031.632.22*
doi:10.5552/drind.2012.1220

ABSTRACT • *This paper presents quality criteria for corner joints of beech chairs by comparison of break moments during static and dynamic testing of the most frequently used type of construction joints: - round mortise and tenon. Laboratory joint testing using discursive construction methods showed a statistically supported value of the achieved results. The purpose of this paper is to investigate the possibility of shortening the testing procedure of final products and evaluate the quality of final products by segment testing of components in the design phase.*
The results showed that there is a significant dependence between the Md/Ms coefficient and the number of testing cycles. This opens the possibility of a new, different approach to testing the strength of constructions, using methods for testing assemblies instead of entire final products in accordance with the applicable standard working methods.

Key words: *wood constructions, sitting furniture, chair joints, strength of glued beechwood joints, round mortise and tenon*

SAŽETAK • *U ovom su radu izneseni kriteriji kvalitete kutnog spoja bukovih stolica usporedbom momenata lomova tijekom statičkoga i dinamičkog ispitivanja najčešće upotrebljavane vrste konstrukcijskog spoja zaobljenim čepom i podužnom rupom. Laboratorijsko ispitivanje spoja uporabom diskurzivnih konstrukcijskih metoda pokazalo je statistički podržanu vrijednost postignutih rezultata. Svrha ovog rada bila je ispitati mogućnost skraćenja postupka ispitivanja gotovih proizvoda te vrednovanje kvalitete gotovih proizvoda uz pomoć segmentnog ispitivanja sastava u fazi projektiranja.*
Rezultati su pokazali da postoji signifikantna ovisnost koeficijenta Md/Ms i broja ciklusa provedenog testiranja. Ta činjenica omogućuje drugačiji, nov pristup ispitivanju izdržljivosti konstrukcija primjenom metoda ispitivanja na sklopovima umjesto na cijelim gotovim proizvodima prema važećim standardiziranim radnim metodama.

Ključne riječi: *drvne konstrukcije, namještaj za sjedenje, spojevi stolica, čvrstoća slijepljenih bukovih spojeva, zaobljeni čep i podužna rupa*

1 INTRODUCTION
1. UVOD

Research in the field of sitting furniture durability was carried out by testing actual products subjected to dynamic loads, as prescribed by the valid standards. On 48 different chair models (Jeršić *et al*. 1978), the joint between the rear legs and side frame was determined as a critical place. In the research (Dzigielewski *et al*. 1983), the influence of the frame position on the achieved number of cycles subjected to a static load of 40, 60 and 80 % was tested. In doing so, the authors mainly investigated the factors affecting construction strength. Due to the high cost of the experiment, the parts exposed to the heaviest loads were investigated,

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namely the rear legs assembly and chair frame. The investigations (Eckelman, 1997; Eckelman, 1989; Tkalec and Prekrat, 1997), were carried out under real conditions. Although computer modelling methods for determination of the quality of chairs or critical joints is not new (Eckelman and Fergus, 1976), this research method has been frequent applied in recent years, (Smardzewski and Papuga, 2004; Warmbier, 1999). There are a large number of papers investigating construction quality; however, only a few deal with the dependence between static and dynamic testing of construction strength.

This paper deals with wooden chairs as the most numerous type of construction in final production, and which are especially significant in terms of their production value and share of lumber and construction elements.

Evaluation and marketing of chairs on the domestic and global markets depends primarily on their quality. One of the quality factors is durability of the glued construction under static and dynamic load during use, as specified by the Croatian sitting furniture standard HRN.D.E2.201.According to this standard, three samples of final products must be taken from regular serial production. The high costs incurred in establishing negative results could be avoided through faster and simpler quality testing. Furthermore, the use of new unconventional design solutions and new materials has become quite common, thereby increasing the need for using discursive methods in furniture construction testing.

The aim of this paper is to determine the possibilities of shortening the quality testing procedure for chairs defined by the existing standards and predicting the degree of construction durability in the design phase. The assumption is that this aim could be achieved by determining the interdependence between results of static and dynamic testing of samples of chair'corner joints.

2 MATERIAL AND METHODS
2. MATERIJAL I METODE

Construction durability testing was carried out on 72 identical chair samples. Samples were grouped into seven classes defined by the effect of force moment of (38.43 Nm, 47.7 Nm. 57, 69 Nm, 68.94 Nm, 76.5 Nm, 87.57 Nm and 96.84 Nm).

Test samples were chosen in line with previous studies of sitting furniture and their assemblies, and were determined by establishing the product critical element (Eckelman and Hincz, 1977; Smardzewski, 1998; Smadzewski and Papuga, 2004; Tkalec, 1985; Wilczynski and Warmbier, 2003), made up of the joint between the rear legs and chair frame, as shown in Figure 1.

Polyvinyl acetate glue Wegocoll HTF (Ehrengruber No. 117461 series 0243B 9K038) was used for experimental gluing of test samples. The glue and wood species (beech) represent constant parameters during the study. Due to the specific characteristics of wood as a material, the quality criteria of material and elements (Prekrat *at al*., 1998) comprising the joint were checked prior to gluing. These characteristics are presented in Tables 1 and 2.

Sample dimensions were adapted to the most frequently produced chairs in accordance with previous studies dealing with similar issues in order to obtain comparable results.

Any corner joint assembly consists of three constituents: legs, side and rear chair frame. Dried con-

Table 1 Physical and chemical characteristics of glue and wood
Tablica 1. Fizikalno-kemijska svojstva ljepila i drva

Quality criteria - *Kriterij kvalitete*		
Material technical data *Tehnički podaci o materijalu*	Wood species / *vrsta drva*	BE
	Growth ring width, mm / *širina goda, mm*	2.5
	Density, kg/m^3 / *gustoća, kg/m^3*	694
	Wood moisture content, % / *sadržaj vode u drvu, %*	10.42
Glue technical data *Tehnički podaci o ljepilu*	Type of glue / *vrsta ljepila*	PVA
	Percentage of dry matter, g / *postotak suhe tvari, g*	57.89
	Layer quantity, g/m^2 / *količina nanosa, g/m^2*	280
	Viscosity, cP / *viskoznost, cP*	14000
	Bonding strength, N/cm^2 / *čvrstoća lijepljenja, N/cm^2*	9.95
	Drying period - until breaking, days / *vrijeme sušenja (do kidanja), dana*	8

Table 2 Features of chair assembly
Tablica 2. Svojstva sklopa stolice

Quality criteria - *Kriterij kvalitete*		
Dimensioning / *Dimenzioniranje*	Frame dimensions, mm / *dimenzije okvirnice, mm*	50x20
	Mortise length and width, mm / dužina i širina čepa, mm	40x20
	Mortise thickness, mm / *debljina čepa, mm*	10
	Gluing surface, cm^2 / *površina lijepljenja, cm^2*	16.45
	Seat, mm / *dosjed, mm*	-0.25
	Pressing extent, mm / *natisnutost, mm*	0.49

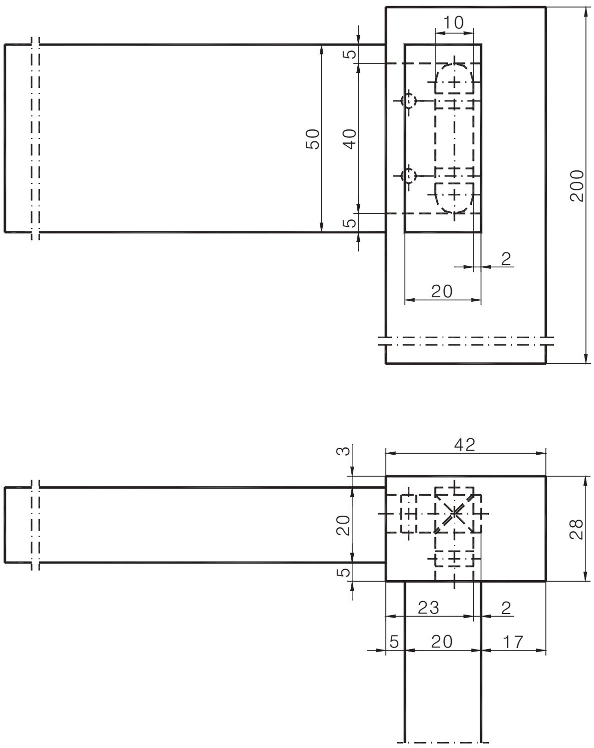

Figure 1. Round-head mortise diagonally shortened in tenons with lengthways hole
Slika 1. Zaobljeni čep koso prikraćen u podužno glodanim rupama

struction elements were sawn from beech, and then planed to the final dimensions using a four-sided plane. Cross-cut dimensions of chair legs were 42 x 28 mm, and the dimensions of the chair frame were 50 x 20 mm. Lengthways holes were made on the leg elements, and round-head mortises on the frames. The elements were glued into a system as shown in Figure 1.

Upon applying the glue on both mortise and tenon adhesion surfaces, the samples were tightened by a force of 3900 N for four minutes in accordance with the manufacturer's recommendation and then air conditioned at a temperature of 19.2 °C and relative humidity of 52.2 %. The average moisture content of samples was controlled using a calibrated electro-resistant moisture metre, and ranged from 9.56 and 11.65 %.

Testing of dynamic strength is carried out on constructions subjected to varying dynamic loads, which is the reason why such constructions are considerably less

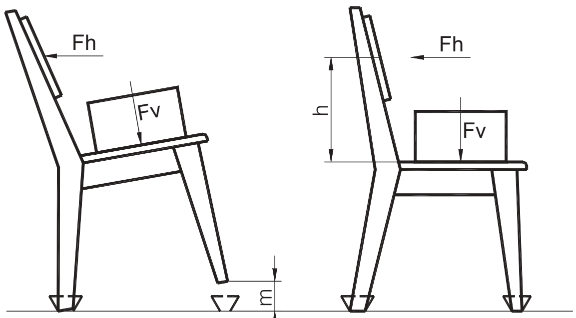

Figure 2. Scheme of chair testing according to standard
Slika 2. Prikaz ispitivanja stolica prema normi

strong then those subjected to a uniform load. In Croatia the procedure for testing sitting furniture (stools, chairs and semi-armchairs) is standardised by the standard HRN.D.E2.201. which is quite similar as EN 1728 and

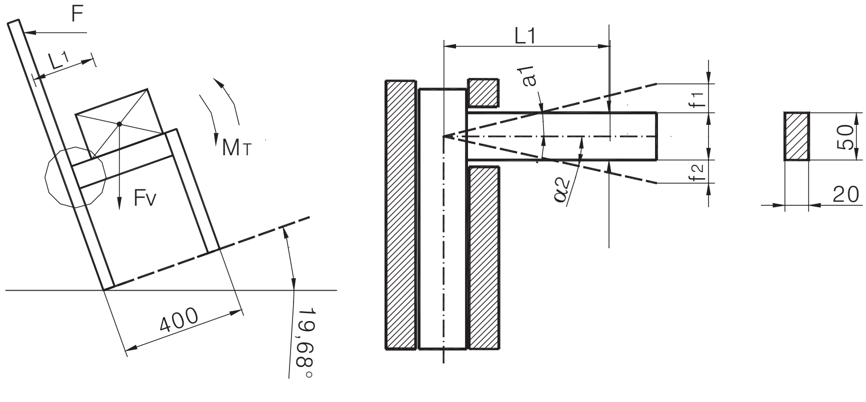

Figure 3. Scheme of dynamic testing samples derived from chair leg assembly
Slika 3. Prikaz uzorka za dinamičko ispitivanje izvedenoga prema modelu nožišta stolice

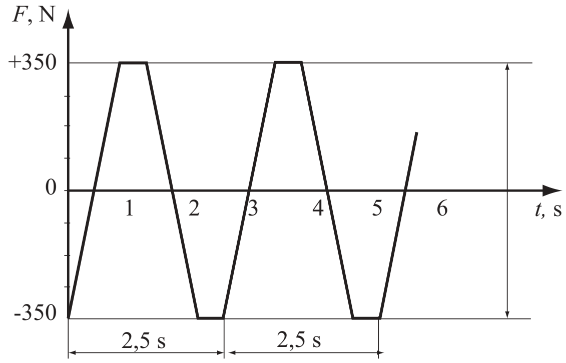

Figure 4 Regime of alternating load during dynamic strength testing
Slika 4. Režim djelovanja naizmjenične sile pri ispitivanju dinamičke čvrstoće

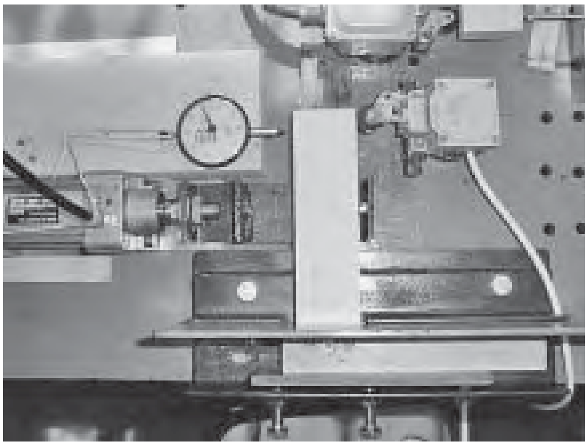

Figure 5 Device for dynamic strength testing
Slika 5. Uređaj za ispitivanje dinamičke čvrstoće

EN 12500. The standard is applied for determining the durability of chairs, and for determining the durability of semi-armchairs. Testing of chair durability subjected to dynamic loads is carried out as shown in Figure 2. Testing of joints is adapted to conditions stated in the above mentioned standards as shown in Figure 3.

The effect of alternating load on the horizontal frame of the chair seat, i.e. on the arm of the presented model is shown in Figure 4. According to this regime, these chair assemblies are subjected to an alternating load every 2.5 seconds.

For the purpose of dynamic strength testing, a pneumatic device was produced with the appropriate instruments for adjusting force and number of impulses per unit of time (Figure 5).

Testing was carried out at seven levels of operating moments ranked accordingly. All seven groups subjected to testing of specific force moments defined in Table 4. Due to the effect of the pulling strength, the occurring deformation or deviation was designated as f_1 and the deformation caused by pressure force or deviation was designated as f_2 (Figure 3).

The break moment is obtained by multiplying break force, arm length and a cosine angle of 19.68°. The break moment results are expressed in Nm. The expression for calculating the break moment is as follows:

$$M_s = F_s \cdot l \cdot \cos\alpha \quad (1)$$

3 RESULTS
3. REZULTATI

In order to apply the Md/Ms coefficient, a comparison was made of the results of static testing of the same samples used in (Prekrat *at al*. 2004). Table 3 shows the results of static break moment testing stated in the above paper for the samples corresponding to those used in this study.

As in Prekrat *at al*. (2004), where the break moment distribution was tested, in this paper testing was also carried out of the normality of distribution of the achieved number of cycles for all seven groups subjected to testing of specific force moments defined in Table 4.

The Kolmogorov-Smirnov test showed that the distribution for the analysed joint was not normally distributed ($p<0.05$). The type of error I of 5 % was considered statistically significant.

Table 3 Descriptive statistics of static break moment data (Nm)
Table 3. Deskriptivna statistika za podatke statičkog momenta loma (Nm)

Number of samples / *Broj uzoraka*	29
Mean value / *Srednja vrijednost*	1543.6
Median / *Medijan*	1543.8
Sum / *Zbroj*	44766.0
Minimum / *Minimum*	1361.2
Maximum / *Maksimum*	1684.9
Variance / *Varijanca*	8250.2
Standard deviation / *Standardna devijacija*	90.83
Standard error / *Standardna greška*	16.86679

Table 4 Descriptive statistics of data for all dynamic break moments (Nm)
Tablica 4. Deskriptivna statistika za podatke svih dinamičkih momenata loma (Nm)

Moment *Moment* Nm	**Mean value** *Srednja vrijednost*	**Median** *Medijan*	**Sum** *Zbroj*	**Minimum** *Minimum*	**Maximum** *Maksimum*	**Variance** *Varijanca*	**Standard deviation** *Standardna devijacija*	**Standard error** *Standardna greška*
96.57	48.44	44.0	436	32	74	208.3	14.43	4.81
87.57	68.12	49.0	1158	18	205	2106.1	45.89	11.13
76.50	185.30	165.0	2038	59	314	11091.0	105.31	31.75
68.94	259.40	228.5	2594	129	556	16632.0	128.96	40.78
57.69	425.00	500.0	5525	227	644	22676.0	150.59	41.77
47.40	900.50	719.5	9005	360	2091	266516.0	516.25	163.25
38.43	7406.20	5902.0	81468	1617	13944	13228553.0	3637.11	1096.63

4 DISCUSSION
4. DISKUSIJA

Many authors have investigated the influence of construction factors of different corner joints used in chair production, and a considerable dependence between gluing strength and the adhesion surface has been established (Wang and Yuang 1994). There are also significant studies that determine the position of corner joints in testing the effects of force (Warmbier 1999). The greatest problem in comparing results is incomplete data on samples or the material they are made from. Joint strength depends on specific sample mass (Wang and Yuang, 1994), and variation was reported in large data dispersion of volume mass of beech wood (*Fagus Sylvatica* L.*)* from different stands (Tkalec, 1985). (Tkalec, 1985) reported the influence of seat and pressing extent of mortise not stated in the papers of other authors. Furthermore, the influence of technological factors is also significant for comparing results, as seen in (Biniek and Smardzewski 1987), where the impact of moisture on joint strength was examined. In the study (Dziegielewski, 1991), dependence between the manner of glue application on the adhesion surfaces and joint strength is outlined as a highly significant technological factor. Furthermore, it is necessary to give a detailed definition of the material and design in standardising the forces of static testing that correspond to a specific number of dynamic testing cycles.

In order to determine the interdependence between static and dynamic testing methods, a previous study (Prekrat *at al*., 2004) was used to calculate the coefficient equal to the quotient of dynamic and static moment of force. Due to insufficiently defined material parameters, there are difficulties in comparing the results with the results listed in the literature. For this reason, the comparison was made on the basis of the said research, whose samples were made under the same conditions and from the same material. The coefficient was calculated for each level of moment of force. The dependence between the results of static and dynamic testing methods was determined by the correlation between the Md/Ms coefficient and the number of achieved cycles for each of the seven different values of moment of force. Table 5 presents the moment values to which the sample was subjected during testing, static and dynamic moments of force, number of achieved cycles until breaking and the calculated coefficient. The correlation is shown in Figure 6.

Table 5. Moments data and coefficients for test samples
Tablica 5. Podaci momenata i koeficijenti za testirane uzorke

***M*d**	***M*s**	**Number of cycles** *Broj ciklusa*	***M*d/*M*s coefficient** *Koeficijent*
Nm	Nm		
38.43	154.36	7406.18	0.248963
47.40	154.36	900.50	0.307074
57.69	154.36	425.00	0.373737
68.94	154.36	259.40	0.446618
76.50	154.36	185.27	0.495595
87.57	154.36	68.12	0.567310
96.57	154.36	48.44	0.625615

The high correlation coefficient (R^2=0.9167) indicates a high dependence between the static and dynamic testing of samples. This dependence indicates the possibility of shortening the long dynamic testing prescribed under the current standards. Figure 6 shows the dependence curve of coefficient k_{ds} and the number of achieved cycles until breakage.

5 CONCLUSIONS
5. ZAKLJUČAK

Based on the corner joints tested in this paper, the following can be concluded:

- a significant correlation was established between the results of static and dynamic testing of joints, using the expressed Md/Ms coefficient and the number of cycles of joints dynamically tested in this paper and in comparison with the results of previous studies;
- the results are applicable to further research in innovating design solutions and in practical application in testing chair quality;

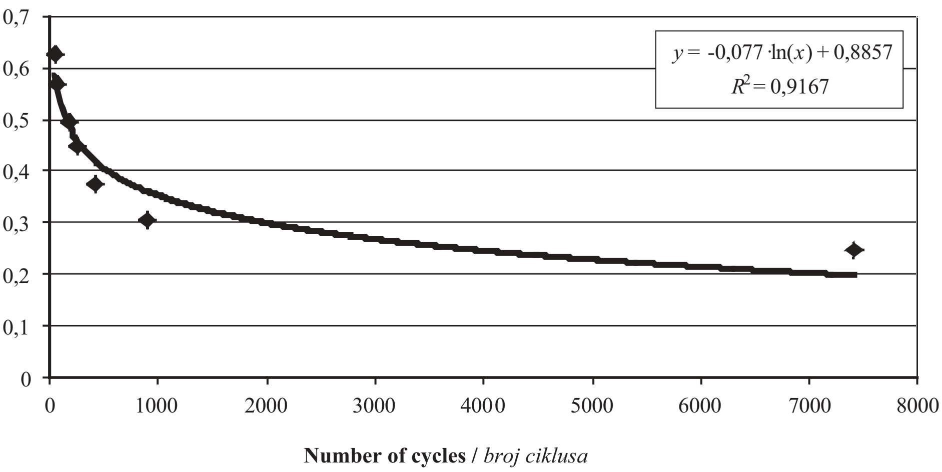

Figure 6 Dependence of the Md/Ms coefficent and cycle number for sample
Slika 6. Ovisnost koeficijenta Md/Ms o broju ciklusa za skupinu uzoraka

- there are other possibilities in the approach to checking quality through the partial testing of key assemblies for the durability of sitting furniture;
- this procedure can considerably contribute to successful planning and manufacturing of industrial products.

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Effect of Hydro- and Hygro-Thermal Treatments on Some Wood Properties of *Pinus Radiata* and *Pseudotsuga Menziesii*

Utjecaj hidrotermičke i higrotermičke obrade na promatrana svojstva drva bora (*Pinus radiata*) i duglazije (*Pseudotsuga menziesii*)

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ABSTRACT • *Heat treatments are related to the action of temperature in successive stages and under controlled conditions, changing the chemical structure of wood. However, the method of treatment used may have a significant effect on the properties of the heat treated wood. In order to assess the effect of the heat treatments on the wood properties, two conifer species were considered, as well as the absence of the air through water and vapor and three levels of temperature (130, 145 and 160 °C). The experiments resulted in twelve treatments or interactions plus controls. This study describes the changes in chemical composition of wood at relatively low temperatures and its interactions with the physical and mechanical properties of the new thermally-modified wood. The analysis of the results indicates that the extractives and degradation products that remain in the wood processed in a closed reactor seem to be a very important factor affecting the results.*

Keywords: *heat treatment, extractives, shrinkage, modulus of elasticity*

SAŽETAK • *Toplinske obrade povezane su s djelovanjem temperature u kontroliranim uvjetima pri čemu se mijenja kemijska struktura drva. Međutim, upotrijebljena metoda toplinske obrade može imati znatan učinak na svojstva toplinski obrađenog drva. Kako bi se procijenio učinak toplinske obrade na svojstva drva, napravljen je eksperiment na dvije vrste drva četinjača, koje su obrađene uz odsutnost zraka upotrebom vode i pare te pri tri različite temperature (130, 145 i 160 °C). Eksperiment je napravljen uz dvanaest kombinacija uvjeta obrade te na kontrolnom uzorku. U radu se opisuju promjene kemijskog sastava drva pri relativno niskim temperaturama i interakcije tih promjena s promjenama fizikalnih i mehaničkih svojstava toplinski modificiranog drva. Analiza rezultata pokazuje da su ekstraktivne tvari i tvari nastale u drvu pri procesu toplinske modifikacije vrlo važni činitelji koji utječu na fizikalna i mehanička svojstva drva.*

Ključne riječi*: toplinska obrada, ekstraktivne tvari, utezanje, modul elastičnosti*

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1 INTRODUCTION
1. UVOD

Heat treatments are based on the action of temperature in successive stages and under controlled conditions, changing the polymeric chemical structures of wood. In general, these treatments cause the wood to exhibit a small loss in strength, in exchange for increased dimensional stability, aesthetic improvements and increased durability.

These improvements were explained through the degradation of pentosans to aldehydes and subsequent condensation of these carbonyl groups to the components of lignin phenols, thus generating a hydrophobic complex that improves the natural properties of wood. The modification of polymers should be done at relatively mild temperatures. When increasing the temperature, side-reactions begin to happen, whereby the pentosans, instead of being transformed into aldehydes, are converted into acids, which catalyze chemical degradation of all polymeric structures of wood (Mohebby, 2003).

However, the method of treatment may have a significant effect on the properties of the heat treated wood. Differences between the processes may be related to the process conditions, i.e. the heating of wood in a sealed reactor allows for the build-up of degradation products that can affect the chemical changes taking place in the wood (Stamm, 1956).

Therefore, the main objective of this study was to assess the influence of thermal treatments, in a closed reactor using a low range of temperature in the absence of the air through water and vapor, on some wood properties of *Pinus radiata* and *Pseudotsuga menziesii*.

2 MATERIAL AND METHODS
2. MATERIJAL I METODE

Pinus radiata and Pseudotsuga menziesii wood was supplied by a wood industry. Samples (70 × 70 × 100 mm) were obtained from both species, and a total of 56 samples were prepared for this experiment. The samples were used to assess the wood properties before the heat treatments, as well as to assess the influence of heat treatments on the properties of modified wood.

In this study, an autoclave was used with a capacity of 200 l with a maximum temperature of 160 °C. A wood dryer was also used. Appropriate instrumentation and equipment were used to characterize chemically the wood, as well as its physical and mechanical properties.

The experimental design used in this study, see Table 1, considered the following variables to assess the effect of heat treatments on wood properties: two species *(Pinus radiata* and *Pseudotsuga menziesii*), the absence of the air through water and vapor (hydrothermal and hygrothermal) and three levels of temperature (130, 145 and 160 °C), with each level of temperature being applied for five hours. The experiments resulted in twelve treatments or interactions plus controls. Subsequently, the heat treated wood was dried until reaching an equilibrium moisture content (EMC) near to

Table 1 Experimental designs and resulting treatments or interactions
Tablica 1. Parametri eksperimenta i rezultirajuće obrade odnosno interakcije

Heat treatments *Toplinska obrada*		**Species** *Vrsta*	**Treatment Code** *Oznaka obrade*
Absence of air through *Odsutnost zraka uz upotrebu*	**Temperature, °C** *Temperatura, °C*		
without treatment / *bez obrade*		*Pinus radiata* (control)	C1
		Pseudotzuga menziesii (control)	C2
water *vode*	130	*Pinus radiata*	1
	145	*Pinus radiata*	2
	160	*Pinus radiata*	3
water *vode*	130	*Pseudotzuga menziesii*	4
	145	*Pseudotzuga menziesii*	5
	160	*Pseudotzuga menziesii*	6
vapor *pare*	130	*Pinus radiata*	7
	145	*Pinus radiata*	8
	160	*Pinus radiata*	9
vapor *pare*	130	*Pseudotzuga menziesii*	10
	145	*Pseudotzuga menziesii*	11
	160	*Pseudotzuga menziesii*	12

10 %. The wood was then put inside an oven for two hours at 200 °C to consolidate the new polymeric structures (Militz, 2002).

Finally, steam conditioning was applied to restore an EMC ranging between 8 to 10 %, allowing for the heat treated wood to be machined afterwards.

The characterization of wood before and after the heat treatment is described as follows. *Chemical composition:* solvent extractives in boiling water, and ethanol toluene according to TAPPI T 204-om-88.1 % sodium hydroxide solubility TAPPI T 212-os-76 and lignin (TAPPI T 222 om-88); *Physical and Mechanical properties:* moisture content, anhydrous density, tangential and radial shrinkage by NCh176/1, 2 and 3 were determined; tests for MOE were also conducted using standard DIN 52 186.

For the analysis, the results were processed to know their distribution and decide on the use of parametric or non parametric statistics.

3 RESULTS AND DISCUSSION
3. REZULTATI I RASPRAVA

3.1 Chemical changes in wood by hydro- and hygro-thermal treatments
3.1. Kemijske promjene u drvu nakon hidrotermičke i higrotermičke obrade

Table 2 shows an average increase of total extractives content, 1 % sodium hydroxide solubility and lignin values in heat treated wood, in comparison with the controls for both conifer species.

However, when comparing between heat treatments, both *Pinus radiate* and *Pseudotsuga menziesii* show that total extractive content values tend to decre-

Table 2 Chemical analysis of hydro- and hygro-thermal treated wood
Tablica 2. Kemijska analiza hidrotermički i higrotermički obrađenog drva

Heat treatment *Toplinska obrada*		**Species** *Vrsta*	**Treat-ment code** *Ozna-ka obrade*	**Chemical composition, %** *Kemijski sastav, %*				
Absence of air through *Odsutnost zraka uz upotrebu*	**Tempera-ture, °C** *Tempera-tura, °C*			**Boiling water extractives** *Ekstraktivi u kipućoj vodi*	**Ethanol toluene extractives** *Ekstraktivi u etanol toluenu*	**Total extracti-ves** *Ukupno ekstraktivi*	**1 % sodium hydroxide solubility** *1 % Otopina natrijeva hidroksida*	**Lignin** *Lignin*
without treatment *bez obrade*		*P. radiata* (control)	C1	2.7	0.4	3.2	12.7	30.7
		P. menziesii (control)	C2	3.7	2.9	4.7	12.6	30.9
water *vode*	130	*P. radiata*	1	8.8	5.5	10.2	21.5	31.1
	145	*P. radiata*	2	9.4	6.9	10.3	20.3	34.4
	160	*P. radiata*	3	6	7.4	9.3	14	40.3
water *vode*	130	*P. menziesii*	4	13.6	10.7	14.4	22.9	43.9
	145	*P. menziesii*	5	12.1	11.8	14.2	20.6	38.7
	160	*P. menziesii*	6	9.4	10.4	12.2	15.7	50.9
vapor *pare*	130	*P. radiata*	7	5	3.3	6	20.7	28.1
	145	*P. radiata*	8	9.7	6.3	11.5	21.4	31.8
	160	*P. radiata*	9	7.7	10.2	12.3	19	37.1
vapor *pare*	130	*P. menziesii*	10	8	4.5	8.3	18.8	35.3
	145	*P. menziesii*	11	14	10.4	13.6	21.5	38.3
	160	*P. menziesii*	12	13.8	14.3	16.2	21.2	44.4

ase in water when the temperature increases. Conversely, under vapor conditions for both species, the extractive content values tend to increase.

In case of the 1 % sodium hydroxide, in water as well as vapor, the values tend to decrease with the increase of temperature; the degradation of hemicellulose can be inferred because these soluble products represent the portion of holocellulose content that remains after boiling water and ethanol.

As shown in Table 2, the use of water or vapor is an important factor to be considered, because they have an effect on the chemical composition of the heat-treated wood. The results in Table 2 suggest that the water heat treatment facilitates the diffusion of degraded sugars and extractives out of the wood, unlike the vapor heat treatment where the degraded sugars and extractives remain in the wood.

Subsequently, the lignin generally increases keeping proportion with the loss of polysaccharide material in heating. Sandermann and Augustin (1964) suggest that, although lignin is thermally more stable than polysaccharide component of the cell wall, some thermal degradation of lignin occurs at relatively low temperatures, with the production of various phenolic degradation products.

3.2 Physical and mechanical changes in wood by hydro- and hygro-thermal treatments
3.2. Promjena fizikalnih i mehaničkih svojstava drva nakon hidrotermičke i higrotermičke obrade

The referential values of density of *Pinus radiata* and *Pseudotsuga menziesii* are approximately 0.45 g/cm^3 and 0.41 g/cm^3, respectively, while the density of the samples for both species were 0.39 g/cm^3 and 0.36 g/cm^3, respectively (see Table 3). This difference is probably due to the fact that most of the wood samples came from the central part of the tree.

As shown in Table 3, the shrinkage in tangential and radial directions was improved for *Pinus radiata* and *Pseudotsuga menziesii* when using both water and vapor. In tangential directions, the control samples coincidentally had the same value for both species (6 %) and some treatments reduced this value to approximately 4 %. On the other hand, after some treatments, the values of control samples for *Pinus radiata* and *Pseudotsuga menziesii* (3.3 % and 3.63 %) were reduced to approximately 2.4 % in the radial directions.

Table 3 also shows the modulus of elasticity (MOE) of *Pinus radiata* and *Pseudotsuga menziesii* wood after a hydro- and hygro–thermal treatment. In general, a loss in strength was observed as temperature increased for both species, either in water or vapor treatment in comparison with the control values. However, for *Pinus radiata* the MOE was higher at 130 °C and then decreased as a function of temperature. This behavior of MOE was also reported for *Eucalyptus globules,* where the apparent modulus of elasticity of the treated wood was a little bit higher than MOE of the original wood (Santos, 2000). Kim *et al.* 1998 found close relationship between the decrease of bending properties in MOE and the temperature in *Pinus radiata* wood treated at 120 °C, 150 °C and 180 °C for 6 to 96 hours.

3.3 Tangential and radial shrinkage in function of hydro- and hygro-thermal treatment
3.3. Tangencijalno i radijalno utezanje u ovisnosti o hidrotermičkoj i higrotermičkoj obradi

Thermally treated wood shows an improvement in both tangential and radial shrinkage, however, these improvements vary depending on the treatment applied.

Table 3 Physical and mechanical properties of hydro- and hygro–thermal treated wood
Tablica 3. Fizikalna i mehanička svojstva hidrotermički i higrotermički obrađenog drva

Heat treatment *Toplinska obrada*				**Physical and mechanical properties** *Fizikalna i mehanička svojstva*			
Absence of air through *Odsutnost zraka uz upotrebu*	**Temperature, °C** *Temperatura, °C*	**Species** *Vrsta*	**Treatment code** *Oznaka obrade*	Density *Gustoća* g/cm^3	Shrinkage *Utezanje* Radial *radijalno* %	Shrinkage *Utezanje* Tangential *Tangencijalno* %	MOE MPa
without treatment *bez obrade*			C1	0.39	3.30	6.00	8728
		P. menziesii (control)	C2	0.36	3.63	6.00	10219
water *vode*	130	*P. radiata*	1	0.37	3.24	5.95	10920
	145	*P. radiata*	2	0.35	2.67	5.02	8874
	160	*P. radiata*	3	0.38	3.00	5.70	7274
water *vode*	130	*P. menziesii*	4	0.36	2.62	4.41	8679
	145	*P. menziesii*	5	0.36	2.74	4.40	8238
	160	*P. menziesii*	6	0.34	2.74	4.08	3197
vapor *pare*	130	*P. radiata*	7	0.40	3.61	6.94	11477
	145	*P. radiata*	8	0.36	2.50	5.24	9576
	160	*P. radiata*	9	0.40	2.38	4.37	5279
vapor *pare*	130	*P. menziesii*	10	0.36	3.13	5.15	9993
	145	*P. menziesii*	11	0.36	2.55	4.07	8963
	160	*P. menziesii*	12	0.34	2.67	4.84	3481

A comparison between heat treatment indicates that tangential and radial shrinkage tend to decrease as a function of temperature. This trend is altered by the effect of wood density and the total extractives content remaining after treatment. Table 3 shows that tangential shrinkage values are high in those treatments where extractives are found in smaller amounts, see Table 2. Conversely, low tangential shrinkage values are found in the treatments where there are more extractives, see Table 2.

Moreover, when comparing the two species, *Pseudotsuga menziesii* has lower tangential shrinkage than *Pinus radiate* in both water and vapor. This is possibly due to the lower density of *Pseudotsuga menziesii.*

On the other hand, the Kruskal–Wallis test was used to compare the effect of treatments on some physical and mechanical responses in heat-treated wood, because the obtained responses did not fit a normal distribution even after transformation of the data.

The Kruskal-Wallis test compares the medians of tangential shrinkage within 12 levels of treatment. Since the *p*-value is less than 0.05, there is statistically significant difference between the medians at a confidence level of 95.0 %.

Figure 1 and 2 show the behavior of tangential and radial shrinkage values, respectively, as a function of the treatments.

The Kruskal–Wallis test compares the medians, which indicate that there are significant differences between treatments. By using the medians, it is also possible to identify which group of treatment is different from the other. Figure 1 shows the treatments 11, 4, 5, 6 and 9 with similar medians. These treatments present the lower median values in tangential shrinkage than the rest of treatments. These results could be explained through the extractives contents, which are high in these treatments, see Table 2. Figures 1 and 2 also show that the lower tangential and radial shrinkage for *Pinus radiata* was the treatment that showed more total extractives content remaining for this species, the treatment 9, see Table 2. Taylor (1974) found that the removal of extractives increases the shrinkage and swelling of wood.

3.4 Modulus of elasticity in the function of hydro- and hygro-thermal treatment
3.4. Modul elastičnosti u ovisnosti o hidrotermičkoj i higrotermičkoj obradi

The Kruskal-Wallis test was used for both physical and mechanical properties to compare the medians of the modulus of elasticity within the 12 levels of treatment. Since the *p*-value is less than 0.05, there is a

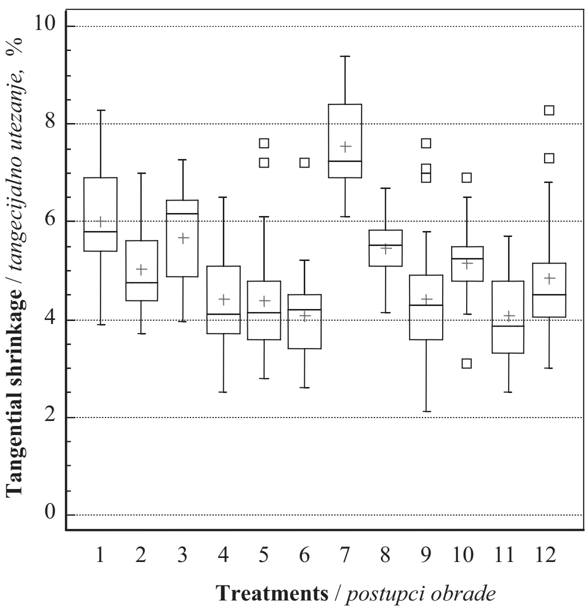

Figure 1 Tangential shrinkage after hydro- and hygro-thermal treatment
Slika 1. Tangencijalno utezanje drva nakon hidrotermičke i higrotermičke obrade

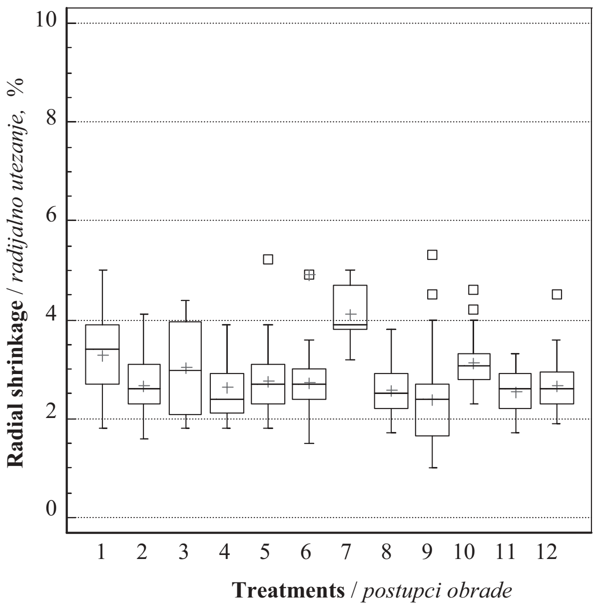

Figure 2 Radial shrinkage after hydro- and hygro-thermal treatment
Slika 2. Radijalno utezanje drva nakon hidrotermičke i higrotermičke obrade

statistically significant difference between the medians at a confidence level of 95.0 %. Figure 3 shows the behavior of the modulus of elasticity values as a function of the treatments.

Figure 3 shows that treatments 6 and 12 produce the lowest values of MOE. These treatments correspond to *Pseudotzuga menziessii* at 160 °C in water and vapor, respectively, possibly due to the lower density of this species.

In the case of *Pinus radiate,* treatment 9, with vapor at 160 °C, showed a MOE lower than treatment 3 (water).

The differences among treatments 9 and 3 could be explained by the wood density, which was higher in samples used for the treatment 9. However, the wood samples used for treatments 12 and 6 have the same average density, and 6 produced a lower MOE than 12, see Table 3. In this case, a possible explanation could be the high level of remaining lignin in comparison with the holocellulose, which indicates a strong degradation of those treatments when using water, see Table 2.

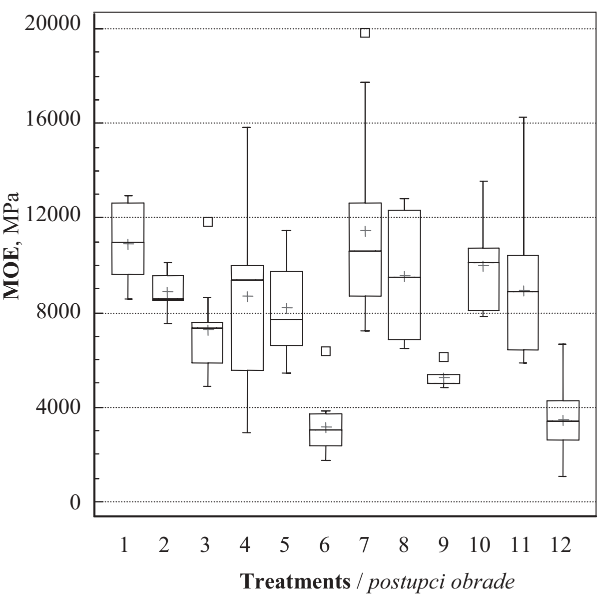

Figure 3 Modulus of elasticity of *Pinus radiata* and *Pseudotsuga menziesii* wood after hydro- and hygro-thermal treatment
Slika 3. Modul elastičnosti drva bora i duglazije nakon hidrotermičke i higrotermičke obrade

Finally, considering that heat treatments alter the relationship between water and wood, it is expected that a reduction in the cell wall moisture content will produce changes in mechanical properties of the wood.

4 CONCLUSION
4. ZAKLJUČAK

Hydro- and hygro-thermal treatments have an effect on the original chemical composition and, therefore, on the properties of *Pinus radiata* and *Pseutozuga menziesii* wood.

The extractives and degradation products that remain in wood processed at low temperature range in a closed reactor seem to be a very important factor affecting the results.

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182

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Determination of Fire and Burning Properties of Spruce Wood

Određivanje zapaljivosti i obilježja gorenja drva smreke

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ABSTRACT • *This paper deals with the determination of selected fire properties of spruce wood. It describes the general characteristics of spruce wood, microscopic and macroscopic features. Broad application of this material requires the assessment of its properties regarding the fire aspects, being a cause of fire in forests or due to frequent occurrence of wildland fires in the Slovak territory, and being a flammable material used in building industry, furniture industry, etc. This paper analyses the following fire properties: flash-ignition temperature, spontaneous-ignition temperature, mass burning rate, ignitability of material exposed to a small open flame.*

Keywords: *spruce, fire properties, flash-ignition temperature, spontaneous-ignition temperature, burning rate, ignitability*

SAŽETAK • *Tema rada je određivanje svojstava zapaljivosti i gorenja drva smreke. Opisuju se opća te mikroskopska i makroskopska obilježja smrekovine. Zbog široke primjene smrekovine vrlo je važna procjena njezinih svojstava zapaljivosti, posebno zato što su u smrekovim šumama na slovačkom području česti požari a smrekovo se drvo često koristi u graditeljstvu, industriji namještaja i sl. Svojstva zapaljivosti i gorenja analizirana u ovom radu jesu flash temperatura zapaljenja, temperatura spontanog zapaljenja, brzina gorenja te zapaljivost materijala izloženoga slaboj otvorenoj vatri.*

Ključne riječi: *smreka, svojstva zapaljivosti, flash temperatura zapaljenja, temperatura spontanog zapaljenja, brzina gorenja, zapaljivost*

1 INTRODUCTION
1. UVOD

Wood is a natural organic material whose extraction, processing and application plays an important role nowadays. Therefore, it is necessary to accept the fact that wood in any form (raw material, semi-finished product, and end product) cannot be exposed to higher temperatures, and this is considered to be an important negative feature, especially when wood is used as a construction material.

Many authors, e.g. Kačíková (2006) and Osvald (2007), deal in their papers with both influence of wood properties on flammability and external conditions affecting thermal degradation of wood.

Based on the flash-ignition temperature and spontaneous-ignition temperature, according to the ISO 871:2006, the relative comparison of a material resistance against ignition can be determined.

Karlsson and Quintere (2000) stated that for reaching the flash-ignition temperature, the temperature in

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the fire compartment should reach 500 to 600 °C or the radiant flux on the floor should be 15 to 20 kW·m^{-2}. The temperatures referred to above are significantly higher than the spontaneous-ignition temperatures of most lignocellulose materials.

The basic fire performance properties of wood, from the point of construction, especially wooden constructions, were analysed by Delichatsios *et al*. (2003). They argued that by using the modified conical calorimeter with the heat flux between 15 and 50 kW·m^{-2}, the other fire characteristics could be derived such as conductivity, thermal capacity, spontaneous-ignition temperature, latent heat, gross heat of combustion, etc. The conclusion was that the heat flux of 18 kW·m^{-2} becomes critical for raw wood.

This paper introduced an assessment of wood properties related to fire performance of spruce wood. It deals with the description of the general characteristics of spruce wood, microscopic and macroscopic features. Furthermore, it focuses on the description of the procedure for determining the selected fire characteristics, especially the flash-ignition temperature, spontaneous-ignition temperature, mass burning rate, and ignitability of material exposed to a small open flame.

Spruce wood is the most widely used wood species in Slovakia (excellent technical properties, handling properties, and large domestic sources). It is the most important wood for processing; it is also used as a construction and auxiliary material in building industry and maintenance, in package making industry, in mining, as a transport construction material, in engineering, in furniture manufacture, plywood, fibrous boards, chipboards, etc. Spruce wood is also very valuable as a highly resonant wood (Korytárová and Osvald, 2000; Požgaj *et al*., 1997).

Taking into account the wide application of this material, it is important to assess it not only from its quality, functionality and utilization aspect, but also from the point of view of its fire performance.

Spruce wood is also used in biomass production. During its combustion, it is important to know all the physical and chemical parameters of combusted materials as well as to study nitrogen oxides that represent the most important toxicological fire products. Nowadays, the concentration can be estimated relatively accurately for the industrial combustion conditions. In industrial combustion, these conditions are set to reach maximum combustion efficiency meeting the emission limits (Martinka *et al*., 2011).

2 MATERIAL AND METHODS
2. MATERIJAL I METODE

2.1 Characteristics of the studied wood: Norway Spruce (*Picea abies* L. Karst)
2.1. Obilježja istraživanog drva: norveška smreka (*Picea abies* L. Karst)

2.1.1 Microscopic features
2.1.1. Mikroskopska obilježja

The wood is without any core, it is fresh and with well a visible zone of ripe wood. Its colour is white or yellowish white, and it turns into yellow under light. The annual rings are clearly visible, narrow summer wood gradually changes into broad spring wood. Resin channels are small and scattered, visible by the eye only on longitudinal well processed cutting profiles as gentle longitudinal darker ruptures. Fresh wood smells like resin. Rays can be visible by the eye. The wood is soft, well splittable and lightweight (ρ = 430 kg·m^{-3}) (Korytárová and Osvald, 2000).

2.1.2 Macroscopic features
2.1.2. Makroskopska obilježja

The basic construction elements of spruce wood are tracheids – vessels that represent up to 94.5…95.3…96.5 % of the whole wood volume. They are 1.7…2.9…3.7 mm long. Rays are dominantly of one layer, consisting of parenchymatous cells; on their circumference, transverse tracheids are located with smooth or weakly waved walls with paired dots. The yield of rays is 4.4…4.7…5.5 %. Spruce wood is characterized by the presence of resin channels well visible on transverse cutting profile – vertical channels. Horizontal channels can be seen on tangential cutting profile. About 30 to 100 vertical resin channels can be found on 1 cm^2 of the transverse cutting profile area of spruce wood. They are mostly present in summer wood and can be seen by the eye as gentle grooves or significant lines on longitudinal cutting profiles. Spruce wood has very narrow resin channels (0.09 mm) and the yield share is 0.2 %. The resin has a protective function for the tree (when the tree is mechanically or biologically damaged) and an impregnation function – it increases the wood resistance against fungi (Korytárová and Osvald, 2000; Požgaj *et al*., 1997).

Physical, mechanical and fire and burning properties of wood are described in many publications, for example by Rowell (2005); the characteristics of spruce wood are introduced in the catalogue of fire and technical properties of materials (The catalogue of fire and burning behaviour properties of materials, 1984). The physical, mechanical and fire and burning properties of spruce wood are presented in Table 1.

2.2. Determination of flash-ignition temperature and spontaneous-ignition temperature
2.2. Određivanje *flash* temperature paljenja i temperature spontanog zapaljenja

Testing was carried out in accordance with the standard STN ISO 871: 1999. The basic terminology is as follows:

- flash-ignition temperature (FIT) is the minimum temperature at which, under specified test conditions, sufficient flammable gases are emitted to ignite momentarily by application of a pilot flame;
- spontaneous-ignition temperature (SIT) is the minimum temperature at which, under specified test conditions, ignition is obtained by heating in the absence of any additional flame source.

The standard is based on the principle of heating a material in the heating chamber of a hot air furnace (see Figure 1) using various temperatures.

Flash-ignition temperature (FIT)

The electric power supplied to the heating coil is adjusted until the air temperature remains constant at the

Table 1 Physical, mechanical and fire and burning properties of spruce wood (Source: *The catalogue of fire and burning behaviour properties of materials. Coniferous wood X*)
Tablica 1. Fizikalna i mehanička svojstva te svojstva zapaljivosti i gorenja drva smreke (Izvor: *The catalogue of fire and burning behaviour properties of materials. Coniferous wood X*)

Physical, mechanical and fire and burning properties of spruce wood *Fizikalna i mehanička svojstva te svojstva zapaljivosti i gorenja drva*	**Value valid for 15 % wood humidity** / *Vrijednosti za drvo sa sadržajem vode 15 %*
Density / *gustoća*	430 kg·m^{-3}
Compressive strength in fibre direction / *tlačna čvrstoća u smjeru vlakanaca*	43 MPa
Bending strength / *čvrstoća na savijanje*	66 MPa
Shearing strength / *smicajna čvrstoća*	6.7 MPa
Elasticity modulus in tension */ modul elastičnosti*	11 000 MPa
Impact toughness / *žilavost*	5 J·cm^{-2}
Hardness (Brinell) / *tvrdoća (prema Brinellu)*	12 N·mm^{-2}
Flash-ignition temperature [STN 64 0149] / *flash temperatura paljenja [STN 64 0149]*	350 – 360 °C
Spontaneous-ignition temperature [STN 64 0149] *temperatura spontanog paljenja [STN 64 0149]*	390 – 400 °C
Oxygen index [STN 64 0756] / *indeks kisika [STN 64 0756]*	25.0 % obj. O_2
Gross heat of combustion [STN 44 1352] / *bruto toplina izgaranja [STN 44 1352]*	19.9 MJ·kg^{-1}
Optical density of smoke / *optička gustoća dima*	7.3 m^2·kg^{-1}
Mass burning rate / *brzina gorenja*	0.056 kg·m^{-2}

desired initial test temperature. The pan with the specimen is inserted into the furnace. The timer is activated, then the pilot flame is ignited and evidence of a flash or mild explosion of combustible gases, which may be followed by continuous burning of the specimen, is observed. Also flame-burning or glowing combustion can occur in case of sudden increasing of the temperature T_1 compared with the temperature T_2. If in 10 minute interval, the flash ignition has occurred, the temperature T_2 is lowered or raised by 50 ºC and the test is repeated with a fresh specimen. If the range in which the flash-ignition temperature is reached has been determined, tests begin at the temperature lower by 10 ºC than the highest temperature and continue by lowering the temperature by another 10 ºC until the temperature at which no ignition occurs in a 10 min interval is reached. The lowest air temperature T_2, at which a flash ignition was observed during the 10 min interval, is considered as the flash-ignition temperature (STN ISO 871:1999).

Spontaneous-ignition temperature (SIT)

The same procedure is carried out as for FIT but without the pilot flame. The lowest air temperature T_2 at which flaming or glowing combustion of the specimen is observed during the 10 min interval is considered as the spontaneous-ignition temperature.

To determine the flash-ignition temperature and spontaneous-ignition temperature, the spruce wood specimens were prepared so as to meet the requirements for sample specimen mass of 3.0 g ± 0.2 g (according to the standard STN ISO 871), while for the comparative purposes these specimens were prepared from the tree trunk, branch and root (the branch and root thickness was lower than 5 mm).

2.3 Determination of the mass burning rate
2.3. Određivanje brzine gorenja (smanjenja mase)

Testing apparatus schematically illustrated in Figure 2 is used for model burning tests. This apparatus

Figure 1 Photo of the apparatus for STN ISO 871
Slika 1. Uređaj za STN ISO 871

consists of the electronic weight (4) with the accuracy of two decimal places, weight protection unit (3), e metal holder (6) for placing testing specimen (5), metal loading frame (2) for placing radiant heat source and infrared thermal heater (1) with the input of 1000 W, heater surface temperature of 652.7 °C, maximum wavelength of 3.11 μm, and radiation intensity of 3.055 W·cm^{-2} (Zaťko, 1993).

Testing procedure – the experiment is based on exposing the testing specimens to the thermal infrared heater (radiant heat source) in 10 minute intervals at the distance of 30 (35, 40, 45 and 50 mm) from the radiating heater surface. During the test, the mass loss is recorded in regular 10 second intervals.

To determine the burning rate in the specified time interval, the absolute burning rate v_a is calculated according to the relation (Osvald and Osvaldová, 2003):

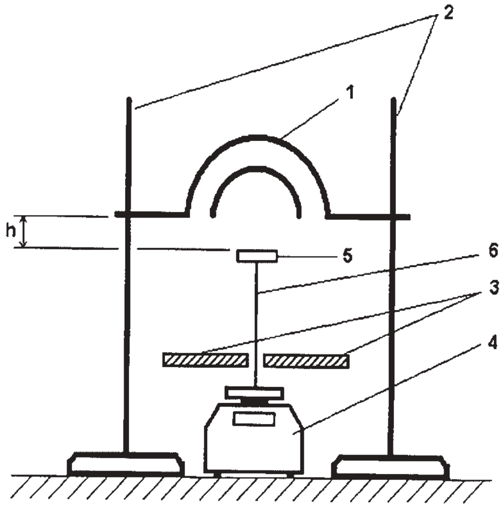

Figure 2 Testing apparatus for the determination of mass burning rate
Slika 2. Uređaj za određivanje brzine gorenja

$$v_a = \frac{m(\tau) - m(\tau + \Delta\tau)}{\Delta\tau} \quad (1)$$

Where:

v_a – absolute burning rate, $g \cdot s^{-1}$ / *apsolutni brzina gorenja,* $g \cdot s^{-1}$

$m(\tau)$ – specimen mass in the time τ, g / *gubitak mase uzorka u vremenu* τ, g

$m(\tau + \Delta\tau)$ – specimen mass in the time $\tau+\Delta\tau$, g / *gubitak mase uzorka u vremenu* $\tau+\Delta\tau$, *g*

$\Delta\tau$ – time interval in which mass values are recorded, s / *vremenski razmak u kojemu se bilježi vrijednost mase, s.*

2.4 Determination of ignitability
2.4. Određivanje zapaljivosti

The testing procedure is determined according to the standard STN EN 11925-2: 2004. This test determines ignitability of a product when exposed to a small flame source. The test is used with different classes of reaction-to-fire B, C, D, E (construction products except floor coverings and thermal insulating products for linear ducts), B_{fl}, C_{fl}, D_{fl}, E_{fl} (floor coverings), and B_L, C_L, D_L, E_L (thermal insulating products for linear ducts).

The testing apparatus consists of a combustion chamber (see Figure 3) made of metal sheet and rustproof steel, equipped with thermal resistant glass doors, enabling access and observation from the front side and a lateral side.

The test specimen is clamped in the specimen holder so that one end and both sides are covered by the holder frames and the exposed end is 30 mm from the end of the frame.

The distance between the burner and the specimen is checked by the relevant spacer. For this purpose two kinds of distance spacers can be used. One is used to measure the distance between the burner and specimen on the specimen front principal surface and the other on the specimen lateral side surface.

The burner is lighted in the vertical position to stabilize the flame. A flame height of 20 mm is adjusted

Figure 3 Combustion chamber according to the STN EN 11925-2
Slika 3. Komora za izgaranje prema STN EN 11925-2

by the burner valve. The turner is tilted to 45° with respect to its vertical axis and moved horizontally until the flame reaches the pre-set contact point with the test specimen.

The timer is switched on at the moment when the flame contacts the test specimen. The flame is applied for 15 s or 30 s (according to the user`s requirement or depending on the reaction-to-fire class) and then the burner is retracted in a smooth continuous manner.

If the flame application time is 15 s, the total test duration is 20 s, starting at the moment when the flame was first applied. If the flame application time is 30 s, the total test duration is 60 s, starting at the moment when the flame was first applied. In both cases the position of flame application is recorded and during the test interval (i.e. during 20 s or 60 s) it is observed whether the specimen ignition occurs and whether the flame spreads in the vertical direction more than 150 mm above the flame application point. At the same time the physical behaviour of the specimen is observed.

3 RESULTS AND DISCUSSION
3. REZULTATI I RASPRAVA

3.1 Determined values of the flash-ignition temperature and spontaneous-ignition temperature
3.1. Vrijednosti *flash* temperature paljenja i temperature spontanog paljenja

The experiment was carried out according to the procedure required by the standard STN ISO 871.

Determined values of the flash-ignition temperature and spontaneous-ignition temperature of the tested specimens as well as the flash-ignition and spontaneous-ignition times are presented in Table 2.

Table 2 clearly shows that by comparison of the flash-ignition temperature (FIT) and spontaneous-igni-

Table 2 Determined values of the flash-ignition temperature (FIT) and spontaneous-ignition temperature (SIT) and times of flash-ignition and spontaneous-ignition of the spruce wood specimens
Tablica 2. Vrijednosti *flash* temperature paljenja (FIT) i temperature spontanog zapaljenja (SIT) te vremena *flash* paljenja i spontanog zapaljenja smrekova drva

Spruce wood *Smrekovina*	**Volume mass of dry material** *Volumna masa suhog materija-la*	**Volume mass after condition-ing** *Volumna masa nakon kondicio-niranja*	**Flash-ignition temperature** *Flash tempera-tura paljenja*	**Flash-ignition time** *Flash vrijeme paljenja*	**Spontaneous-ignition tem-perature** *Temperatura spontanog zapaljenja*	**Spontaneous-ignition time** *Vrijeme spontanog zapaljenja*
	$kg \cdot m^{-3}$	$kg \cdot m^{-3}$	°C	s	°C	s
trunk / *deblo*	430	486	370	560	400	550
branch / *grana*	440	483	390	420	460	395
root / *korijen*	410	452	380	485	440	370

tion temperature (SIT) of the spruce tree trunk, branch and root, the lowest values (370 and 400 °C) were determined for specimens prepared from the trunk (those results are comparable with those referred to in Table 1), higher values (380 and 440 °C) of both temperatures were reached by specimens made from the root. The highest temperatures FIT (390 °C) and SIT (460 °C) were observed for the spruce branch specimens.

From the fire prevention point of view, besides temperature, the time also plays a significant role. Table 2 points out the higher variability of results due to reached time values for the flash-ignition that varies from 420 s for the branch specimens to 485 s for the root specimens and up to 560 s for the trunk specimens.

Similar variability can also be seen with the spontaneous-ignition. These values vary in the range from 370 s for the root specimens, 395 s for the branch specimens and 550 s for the trunk specimens. With the higher temperatures, at which the flash-ignition and spontaneous-ignition occur for the branch and root specimens, shorter times were observed of flash-ignition and spontaneous-ignition.

For the Australian pine tree, Delichatsios *et al.* (2003) recorded the spontaneous-ignition temperature of approximately 478 °C, which is comparable with the temperature reached by the spruce branch specimens (460 °C) in this experiment. Also Hagen *et al.* (2009) refer to the spontaneous-ignition temperature of 487.9 °C in the case of the Norway Spruce wood specimens not treated by fire retardant, which is also comparable with our results for spruce branch specimens.

3.2 Determined values of the mass burning rate
3.2. Vrijednosti brzine gorenja

The variation of mass burning rate depends on changed distance of the tested specimen from the heat source. The results are shown in Figure 4, where the maximum burning rate values as well as the time required for reaching these maximum burning rate values are referred to.

Based on the variation of mass burning rate curves shown in Figure 3, it may be stated that maximum burning rates can be observed within the whole time interval, during which the specimens were exposed to

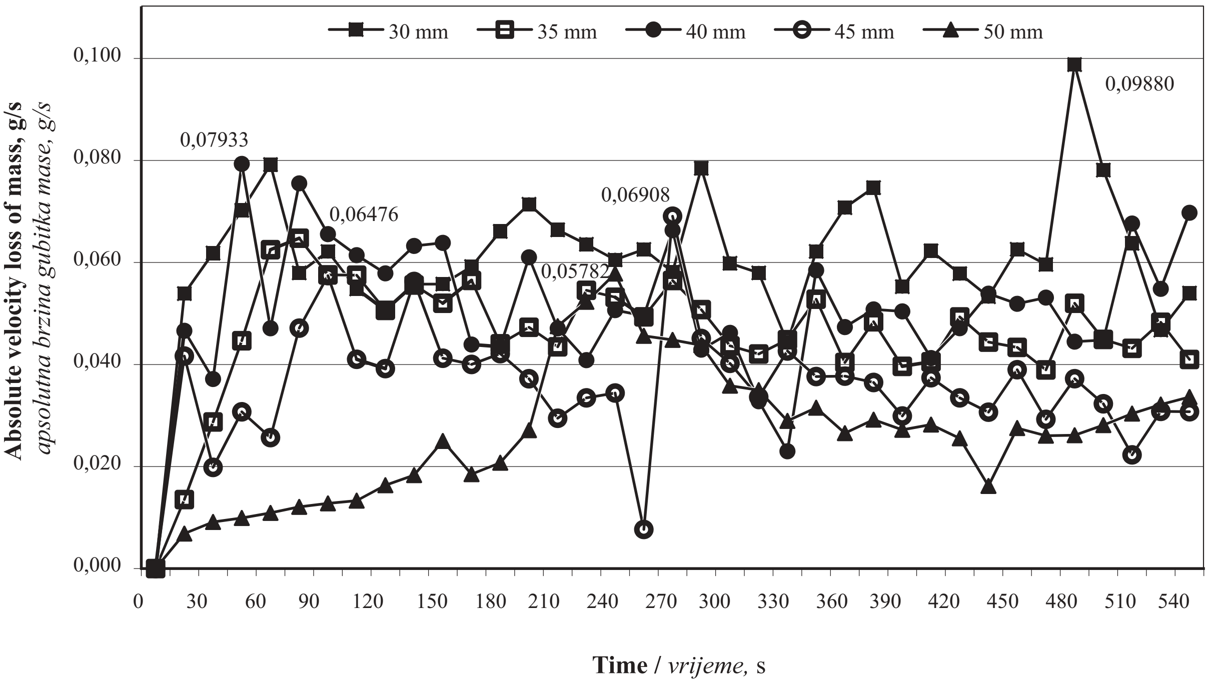

Figure 4 Absolute burning rate of the spruce wood
Slika 4. Apsolutna brzina gubitka mase smrekova drva

Table 3 Values representing burning rate and burning time of the spruce specimens
Tablica 3. Vrijednosti brzine gorenja i vremena gorenja uzoraka od smrekovine

Value / *Vrijednost*	**Distance between specimen and heat source, mm** *Udaljenost između uzorka i izvora topline, mm*				
	30	35	40	45	50
maximum burning rate, $g \cdot s^{-1}$ *maksimalna brzina gorenja , $g \cdot s^{-1}$*	0.0988	0.06476	0.07933	0.06908	0.05782
time for reaching maximum burning rate, s *vrijeme postizanja maksimalne brzine gorenja, s*	480	75	45	270	240

the thermal loading. The spruce specimens located at the shortest (30 cm) distance from the heat source reached the highest value of the mass burning rate (in particular in the last test phase), and on the other hand, the specimens located at the furthest distance (50 mm) from the heat source, reached the lowest maximum burning rate.

Based on the test results, it could be stated that the thermal degradation of material is definitely affected by the distance of the heat source.

The burning speed of spruce wood samples was also introduced in the study by Chrebet *et al*. (2011), where they used a substantially lower speed of burning. The values varied in the range from 0.0054 to 0.0072 g/s. Comparing those results with the results of our experiment, it can be concluded that the reason for lower speed values was the difference in the initial phase of sample burning, where it took 26 s for the samples at a distance of 30 mm from the source, to start burning.

3.3 Determined values of ignitability
3.3 Dobivene vrijednosti zapaljivosti

The experiment was carried out with spruce specimens having dimensions of 250 x 90 x 10 mm carved in a longitudinal direction. The specimens were tested at 30 s intervals according to the procedure described in the Methods. The flame source was applied in two ways: flame exposure of the front principal area and flame exposure of the lateral side surface (edge) of the specimen. The results are presented in Table 4.

Table 4 shows the differences in ignitability depending on the way of flame exposure to specimens. When the specimens were tested on the surface flame application point (on the front principal area), the ignition occurred in one case only. However, by testing the specimen edge flame exposure (edge flame application point), the ignition occurred in all three cases. These results confirmed the higher ignitability of edges.

Based on this testing, it can be concluded that in no case (neither at the surface flame exposure nor edge flame exposure) the flame height in the vertical direction was higher than 150 mm during 60 s (test duration). It means that the criterion $F_s \leq 150$ mm during 60 s (according to Table 1 in the standard STN EN 13501-1 + A1) for the reaction-to-fire classification into the relevant reaction-to-fire class was fulfilled.

4 CONCLUSION
4. ZAKLJUČAK

This paper briefly describes three ways for evaluating fire and burning properties of spruce wood.

It can be stated that every experiment (through its evaluation method) and the results obtained contribute to knowledge in the area of material assessment as regards fire protection, for example:

- The results of the experiment related to the evaluation of the flash-ignition temperature and spontaneous-ignition temperature as well as the times of flash-ignition and spontaneous-ignition of spruce wood showed differences depending on the part of the spruce tree (trunk, branch, root) of which the specimens were made;
- By the evaluation of the mass burning rate, it was established that the value of the maximum burning rate depends on the distance between the tested sample and the initiating heat source;
- The ignitability test showed the difference of ignitability depending on the way of flame exposure to specimens – exposure of the lateral side surface (edge) is more sensitive to ignition than the exposure of the main surface.

Table 4 Evaluation of flame exposure of front (principal) and lateral side surface (edge) of spruce specimens
Tablica 4. Procjena izloženosti plamenu prednje strane (osnovice) i bočne strane (ruba) smrekovih uzoraka

Flame application point / *Točka primjene plamena*	**Surface** / *Površina*			**Edge** / *Rub*		
Application time / *Vrijeme primjene*	30 seconds / *sekundi*			30 seconds / 30 *sekundi*		
Specimen number / *Broj uzorka*	1	2	3	1	2	3
Ignition of the specimen (yes/no) *Paljenje uzorka (da / ne)*	no ne	no ne	yes da	yes da	yes da	yes da
Time of ignition, s / *Vrijeme zapaljenja, s*	–	–	29	26	28	22
Flame spreading to 150 mm distance (yes/no) *Širenje plamena na 150 mm udaljenosti (da / ne)*	no ne	no ne	no ne	no ne	no ne	no ne
Time of flame spreading to 150 mm distance, s *Vrijeme širenja plamena na udaljenost 150 mm, s*	–	–	–	–	–	–

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Međunarodno znanstveno savjetovanje WoodEMA 2012

U organizaciji Katedre za marketinšku komunikaciju Fakulteta za masmedijalnu komunikaciju Univerziteta St. Ciril i Metodij u Trnavi i međunarodne asocijacije za ekonomiku i menadžment u preradi drva i proizvodnji namještaja WoodEMA, i.a. u Trnavi (Slovačka) od 6. do 8. lipnja 2012. godine održano je 5. međunarodno znanstveno savjetovanje *WoodEMA 2012 – Wood and furniture industry in times of change – new trends and challenges*.

Za savjetovanje su na 34 rada prijavljena 62 autora iz devet europskih zemalja. Savjetovanju je nazočilo 38 autora.

P. Alač, Š. Barcik, M. Kvietkova, V. Demoč i R. Rajnoha (Slovačka i Češka) održali su predavanje o planiranju proizvodnje i njegovoj važnosti u cjelokupnome menadžerskom procesu.

K. Bičanić, K. Greger, T. Grladinović, I. Perić i V. Čošić (Hrvatska) u svom su se radu bavili certifikacijom i odgovornim upravljanjem šumama u praksi.

A. Bobovnicky (Slovačka) obradio je održivi model upravljanja drvoprerađivačkom industrijom u nestabilnome poslovnom okruženju.

D. Jelačić, A. Pirc Barčić i V. Čošić (Hrvatska) u svom su radu predstavili stanje prerade drva i proizvodnje namještaja u promotivnim aktivnostima u hrvatskim medijima.

M. Jošt, L. Oblak, A. Zupančič i J. Kos (Slovenija) predstavili su rad o korištenju elementima marketinške komunikacije u slovenskim drvnim tvrtkama.

J. Kropivšek, L. Oblak, P. Grošelj i A. Zupančić (Slovenija) dali su prikaz razvoja modela kompetencija u slovenskim drvnim tvrtkama.

Sudionici međunarodne konferencije WoodEMA 2012 na predavanju
Participants of WoodEMA 2012 international conference during presentations

Predsjednik WoodEMA izv. prof. dr. sc. Darko Motik otvara konferenciju
President of WoodEMA assoc.prof. Darko Motik opens the conference

A. Kusa (Slovačka) predstavila je primjenu metodologije marketinškog miksa za određene drvne proizvode.

M. Kvietkova i Š. Barcik (Slovačka i Češka) dali su prikaz ekonomske održivosti primjene CNC tehnologije u malim slovačkim pogonima za preradu drva.

M. Moro, D. Motik, A. Pirc Barčić i L. Oblak (Hrvatska i Slovenija) u svom su se radu bavili modelom predviđanja uvoza i izvoza namještaja.

S. Petrović (Srbija) dala je prikaz ekocertifikacije drvnih goriva i njezina doprinosa klimatskim promjenama.

H. Pravdova (Slovačka) predstavila je komunikacijske alate u marektingu izdavačke kuće pri izdavanju periodičnih izdanja za drvnoprerađivačku djelatnost.

R. Stasiak-Betlejewska i S. Borkowski (Poljska) predstavili su klastere kao podupirući element razvoja pasivnih drvnih kuća.

R. Stasiak-Betlejewska (Poljska) obradila je učinke promocije pasivnih kuća u Europi.

A. Sujova i R. Rajnoha (Slovačka i Češka) dali su prikaz vrednovanja kompetitivnih čimbenika u drvnoj struci kao bazu za upravljanje poslovnim procesom.

A. Štefančikova (Slovačka) prikazala je pojedine aspekte uključivanja ljudskih resursa u sustav upravljanja kvalitetom u drvnim tvrtkama.

A. Zauškova i A. Madlenak (Slovačka) osvrnuli su se na uvođenje otvorenoga inovativnog koncepta u proizvodnju namještaja.

B. Glavonjić i P. Sretenović (Srbija) u svom su radu obradili ekološke i ekonomske koristi od upotrebe drvnog biogoriva i njegov utjecaj na klimatske promjene.

Tjiekom posjeta tvrtki Swedwood Spartan
Visiting Swedwood Spartan company

Ž. Meloska i I. Petrovska (Makedonija) prezentirali su međunarodnu razmjenu piljenog drva Makedonije.

R. Novakova i A. Tomankova (Slovačka) predstavili su efikasno planiranje marketinške komunikacije u preradi drva i proizvodnji namještaja.

S. Posavec, M. Beljan, K. Šporčić i M. Landekić (Hrvatska) prikazali su načine upravljanja šumarstvom u Hrvatskoj.

E. Šebelova (Češka) dala je prikaz predviđanja troškova i cijena u proizvodnji namještaja primjenom CAD modula.

J. Štepanek i T. Najbrt (Češka) predstavili su stanje i trenutačne ekonomske probleme češke proizvodnje namještaja.

K. Teplicka (Slovačka) dala je prikaz kreiranja cijena u pojedinačnoj proizvodnji namještaja.

L. Abdrabou (Slovačka) predstavila je način promocije drvenih kuća u Slovačkoj.

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P. Kindl (Slovačka) dao je prikaz emitiranja onečišćenog zraka u proizvodnji ojastučenog namještaja.

I. Kintlerova (Slovačka) predstavila je mogućnosti osobnog marketinga u drvoprerađivačkim tvrtkama.

I. Kopčany (Slovačka) prikazao je značenje fotografije u promotivnim materijalima tvrtki za proizvodnju namještaja.

I. Perić, R. Ojurović, T. Grladinović, K. Bičanić i K. Greger (Hrvatska) obradili su prednosti ulaganja u energetski štedljivu tehnologiju u preradi drva i proizvodnji namještaja.

K. Radharth (Austrija) u svojem je radu predstavila značenje inovacije utemeljene na korisnicima u malim i srednjim tvrtkama.

R. Rybansky i M. Ondrušova (Slovačka) bavili su se promjenama u alatima marketinške komunikacije u drvoprerađivačkoj djelatnosti.

K. Štefančikova (Slovačka) u svom je radu govorila o novim trendovima u integraciji lanca ponude i drvoprerađivačkih kompanija.

Z. Tončikova (Slovačka) dala je temelje integraciji ekodizajna u procesu oblikovanja namještaja, a A. Vadkertiova (Slovačka) u svom je radu predstavila ulogu Sveučilišta u odnosima s drvoprerađivačkom djelatnošću.

Uz međunarodno znanstveno savjetovanje, prema ustaljenom redoslijedu, održana je i redovita generalna skupština WoodEMA asocijacije. Uz ostale zaključke, primljeni su novi članovi iz tri europske zemlje (Hrvatske, Italije i Slovačke). Istodobno, održana je i natjecateljska izložba fotografija studenata Fakulteta za masmedijsku komunikaciju na temu *Drvo - nekad i sad.*

Tijekom savjetovanja organiziran je stručni posjet poduzeću za proizvodnju uredskog namještaja Swedwood Spartan u Trnavi.

Generalni tajnik WoodEMA, i.a.
prof. dr. sc. Denis Jelačić

Sudionici savjetovanja WoodEMA 2012
WoodEMA 2012 conference participants

TRENDOVI U OBLIKOVANJU NAMJEŠTAJA I INTERIJERA

I Saloni, Milano 2012

Milano – grad kulture, povijesti, arhitekture, mode, industrije, športa, ali i grad dizajna i noviteta na području namještaja i opremanja interijera, što se ponajbolje ogleda u travnju. Naime, sredinom travnja Milano otvara vrata jednoga od svjetski najpoznatijih sajmova namještaja i prateće industrije te okuplja najprestižnije talijanske i svjetske tvrtke, proizvođače i trgovce, kao i mlade dizajnere na jednome mjestu – na poznatome *I Saloneu*.

Od 17. do 22. travnja ove godine *I Saloni* je okupio nekoliko manifestacija pod nazivima *Salone Internazionale del Mobile, Eurocucina, TFK* (*Technology* for the Kitchen), *Salone Internazionale del Complemento d'Arredo, Salone Internazionale del Bagno* te *Salone Satellite.* Uz navedene događaje na samom sajmu, najveći dokaz da Milano u navedenom razdoblju živi kao pravi dizajnerski grad jesu događaji koji su se zbivali izvan samog sajma, točnije, u središtu grada ili u industrijskim zonama, na Ventura Lambrate, Tortoni i drugim atraktivnim lokcijama (sl. 1) (više na fuorisalone.it).

Sajam je ove godine bio znatno veći nego lani, što je potvrdio i statistički broj dobiven iz Press centra nakon završetka svih događaja. Prema tim podatcima, na sajmu je sudjelovalo i svoje izloške prezentiralo više od 2 700 izlagača (podsjetimo se, prije dvije godine bilo ih je 1 326). Izložbeni je prostor bio dvostruko veći, protezao se na 209 000 m² (2012. godine taj je prostor bio 142 586,5 m²), a u šest dana posjetilo ga je ukupno 331 649 posjetitelja.

I Saloni je još jedanput pokazao da je jedan od vodećih sajmova u tom sektoru u svijetu, bez obzira na krizu koja i dalje ne jenjava. Ovogodišnje, 51. izdanje sajma potvrdilo je da je riječ o velikome medijskom fenomenu i neiscrpnom pokazatelju navika i kulture oblikovanja prostora. Bez obzira na nedostatak inovacija i pravih „novosti“ na području dizajna, ako nešto možemo istaknuti, to su kvaliteta, dobar dizajn i funkcionalnost kao vodilje ovogodišnjeg *I Salonea*.

Naglasak je ove godine bio na bijenalno izloženim kupaonicama i kuhinjama te na njihovoj pratećoj opremi.

Šetnja kroz *I Salone*

Kao potvrda uspješne 50- godišnje tradicije, milanski je sajam ušao u novo razdoblje pod motom *Milano. Gdje drugdje? (A Milano. Dove, se no?)*. Posljednjih nekoliko godina kriza ostavlja osjetan trag na svim područjima, osobito u dizajnu, inovacijama i proizvodnji. Ipak, bez obzira na stanje koje ni dalje nije blistavo, ove se godine izlagači na *I Saloniu* nisu dali „omesti“ težinom realnosti i tmine nego su se, naprotiv, pozitivno i s mnogo entuzijazma prilagodili situaciji. Proizvodi i dalje odišu kvalitetom, vizualnom čistoćom i skladom, besprijekornim estetskim ugođajem, kvalitetnim konstrukcijskim rješenjima, novim materijalima i funkcionalnošću, no bez pretjerivanja u suvišnim detaljima i bespredmetnom elitizmu na području suvremenog dizajna. Paviljoni pod nazivima *Design* i *Modern* zaista su pokazali da Talijani uistinu barataju elegancijom i kvalitetom, formom, materijalima i fenomenalnim minucioznim detaljima koji povećavaju doživljaj svakog proizvoda.

Neke su značajke i dalje u trendu i, odlično su vidljive u spomenutim paviljonima. Bijela ili svijetla pastelna boja (krem, siva), bijelo obojena stakla ili pastelne tkanine i koža neizostavni su na većini elemenata namještaja, bez obzira na to je li riječ o komodama ili blagovaoničkim stolovima, ojastučenom namještaju (sl. 2), kuhinji, spavaćoj sobi (sl. 3), dnevnom boravku ili nekom drugom prostoru u stanu.

Slika 1. Atmosfera izvan sajma, zona *Tortona*

Slika 2. Ojastučena garnitura *Mobius*, dizajn Asnago, proizvođač Giorgetti

Slika 3. Profinjena elegancija spavaće sobe: krevet i noćni ormarić iz garniture IRA dizajnera Chi Wing Loa, proizvođač Giorgetti

Bijela je boja obvezno „začinjena“ toplim drvom (što je vidljivo na svim prikazanim primjerima, nap. a.), ovog puta isključivo mat površinske obrade. Najčešća je uporaba orahovine, nešto rjeđa hrastovine (natur, blago četkane) i egzota. Bukovine ili drva javora moglo se naći samo u tragovima.

No sklonost Talijana kiču i „sladunjavosti“ i dalje je nezaobilazna, pa su, kao i svake godine, svoje mjesto dobili opravdano i izlagači u paviljonima pod nazivom *Classic* (sl. 4).

Povrat *retro* stilova nije toliko odraz želje suvremenog kupca da uistinu posjeduje takav komad namještaja u svom domu, nego utjecaja istočnog tržišta (Rusije, Kine), koje je počelo diktirati vlastiti ukus i odražavati potrebe njihovih bogatih korisnika, zaljubljenih u raskoš i sjaj. Stoga se na sajmu ove godine moglo naći dosta *retro* elemenata u skladu s „novim“, „blještećim“ ukusom kupaca, a i morali su biti „pojačani“ Swarowski detaljima na ručkicama namještaja i dekorativnim furnirom (sl. 5), kožom, ili “pufastim“ i kožnim ojastučenim garniturama (sl. 6).

No da sve *retro* nije nužno u sukobu s dobrim ukusom, pokazali su pojedini elementi namještaja poput sofisticiranih i elegantnih elemenata iz kolekcije Bourgeois, radni stol i komoda tvrtke Baxter dizajnera Mattea Thuna i Antonia Rodruigueza (sl. 7).

Slika 4. Blagovaonička garnitura, izlagač Turri, paviljon *Classic*

Slika 5. Izložbeni prostor tvrtke Bordingnon

Slika 6. Trosjed *Alfred*, dizajn Draga Obradovic i Aurel K. Basedow, proizvođač Baxter

Slika 7. Radni stol i komoda iz kolekcije *Bourgeois*, dizajn Matteo Thun i Antonio Rodruiguez, proizvođač Baxter

Slika 8. Stolica-ljuljačka *Vieques*, dizajn Patricia Urquiola, proizvođač Kettal

Od kada se dizajn etablirao kao neizostavan argument dobrog proizvoda koji povećava konkurentnost, proizvođači na sajmovima ističu autore svojih noviteta. Dizajnerski proizvod postaje razlog da se svaka tvrtka prezentira u punom sjaju. Tako proizvođači/ izlagači uz pomoć potpisa dizajnera ističu svoj proizvod uzdižu ga na pijedestal u punom sjaju, a sebe pokušavaju etablirati „uspješnijima“. Tako već godinama imena dizajnera koja su zabilježena ispod samog proizvoda (ili sad već obilježavaju i zidove!) postaju zaslužna za uspjeh, sjaj i nadmetanje među tvrtkama. Dizajneri postaju medijske zvijezde u pravom smislu. No, je li to opravdano ili ne, najčešće nakon nekog vremena pokazuje samo tržište.

Takvo „nadvikivanje“ proizvodima danas je etabliralo nekolicinu međunarodnih dizajnerskh imena koja, godinu za godinom, lansiraju nove proizvode (npr. Urquiolla, Boroullec, Thun, Rodrigues i brojni drugi). Ti proizvodi vizualno odlično izgledaju, nerijetko nude nove koncepte i nove pristupe u primjeni novih materijala i osmišljavanju svakodnevnog prostora stanovanja.

Odličan je primjer toga osuvremenjena stolica-ljuljačka *Kettal Vieques*, koju je za tvrtku Kettal dizajnirala Patricia Urquiola (sl. 8). Proizvod je dobio i Top design Award 2012 na Atrena Designu 2012 u Poznańu.

Drugi je primjer vitrina tvrtke Riva 1920, koju je za Rivu osmislio Matteo Thun (sl. 9).

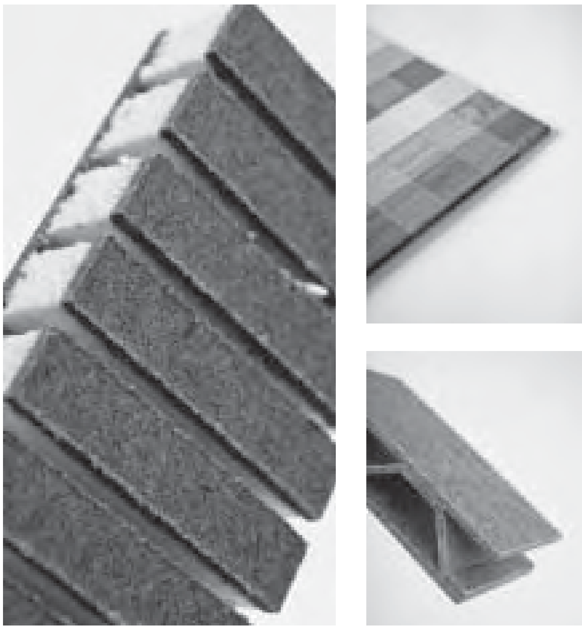
Lansirani kao noviteti, takvi će se proizvodi, nesumnjivo, dobro i skupo prodavati…

Da samo dizajneri ne bi bili u središtu pozornosti, ovogodišnji se sajam pobrinuo stavljajući naglasak na nove materijale. Tvrtka Material ConneXion svake godine lansira nekoliko novih i inovativnih materijala. Osnova mogu biti drvo, polimeri, staklena vlakna ili drugi dodaci, ovisno o namjeni materijala, točnije, novog proizvoda. Primjeri su prikazani na slici 10, iako treba napomenuti da svaka slika, nažalost, ne može vjerno reproducirati kakve prednosti, vizualna, taktilna ili druga svojstva u stvarnosti ima pojedini materijal ako se ne dotakne, pomiriše ili pogleda.

Nenadmašna *Eurocucina*

Svake druge godine popularno zvani „kuhnjari“ i njihove tehnološke pratilje pod nazivima *Eurocucina* i

Slika 9. Vitrina Light, dizajn Matteo Thun, proizvođač Riva 1920.



Slika 10. Neki primjeri novih materijala s dodatkom drva kao osnovne sirovine

Technology for the Kitchen (TFK) imaju priliku pokazati svoje novitete u oblikovanju elemenata kuhinja i opreme. Mirisi koji su se ove godine širili paviljonima, kao i vreva u pojedinim izlagačkim prostorima dali su dodatnu draž paviljonima *Eurocucin*e (sl. 11).

U navedenim su paviljonima prikazane kuhinje od različitih materijala, u rasponu od klasičnih do modernih. Metal, opeka i drvo materijali su tih kuhinja, s tim da je naglasak na prirodnim rješenjima. Kuhinja je predstavljena kao prostor pohranjivanja, pripreme i konzumacije hrane, ali i kao prostor za zabavu i druženje. Prvi put izložba kuhinja obuhvatila je i sve kuhinjske dodatke koji su nužni za rad: posuđe, stolne ukrase te trendove u načinu uređenja stola.

Mnogobrojni proizvođači kuhinjskog namještaja predstavili su izuzetno funkcionalne i estetski skladno i funkcionalno oblikovane proizvode (sl. 12). Prevladavaju ravne površine te velike i prostrane kuhinje s integralnim središnjim pultom koji je vrlo funkcionalan. Od materijala je najzastupljenije cjelovito drvo (hrastovina), lagano pjeskareno ili četkano, te površinski obrađeno tako da se što manje naruši prirodnost drva. Obrada površina uljima i voskovima slabo je zastupljena. Mnogi su proizvođači na svojim proizvodi-

Slika 11. Atmosfera u paviljonima *Eurocucine*

ma kao važan estetski detalj istaknuli zdrave kvrge, male pukotine te nehomogenost građe drva . S obzirom na to da prevladava cjelovito drvo, cilj mnogih dizajnera bio je naglasiti i istaknuti spojeve i vezove. Nezaobilazni dio svake kuhinje je okov (svakoj kuhinji daje neku drugu eleganciju) i elektronika koja korisniku olakšava upotrebu.

U sklopu *Eurocucin*e na sajmu je već tradicionalno sudjelovala hrvatska tvrtka Ancona iz Đakova. Na površini od 60 m² bila je izložena suvremena kuhinja iz njihova najnovijeg asortimana (sl. 13). Prema riječima g. Markice, direktora tvrtke, koji je na slici spremno pozirao našem timu (sl. 14), „iskazan je veliki međunarodni interes za ovaj hrvatski proizvod“, što može biti znatan poticaj hrvatskoj proizvodnji za daljnje uključivanje na međunarodno tržište namještaja i opreme, kao i osiguranje kontinuiteta u izlaganju na međunarodnim sajmovima.

Technology for Kitchen (TFK)

U paviljonu posvećenome tehnologijama u kuhinji izlagali su svi važniji europski proizvođači bijele tehnike, kućanskih aparata ali i okova, koji su nezaobilazan dio svake suvremene kuhinje (sl. 15). Za srednju klasu kućanskih aparata ušteda električne energije i vode vrlo je bitna, pa su aparati energetski visoko štedljivi, nasuprot luksuzu u kojemu taj parametar i ne

Slika 12. Profinjena elegancija suvremene kuhinje

Slika 13. Izlagački prostor hrvatske tvrtke *Ancona* Đakovo, *Eurocucina 2012*

Slika 14. Tvrtka *Ancona* Đakovo na *Eurocucini 2012*

postoji. Uz novitete u kućanskim aparatima, izloženi su i novi koncepti njihova slaganja i oblikovanja kuhinjskog prostora (sl. 16).

Od okova prevladava metalni s naglaskom na funkcionalnost, trajnost i pouzdanost u uporabi. Suvremeni okov omogućuje iskorištenje svih nedostupnih dijelova kuhinje. Rasvjeta je nezaobilazan, sastavni dio svake kuhinje, a skrivena je u elementima korpusa, ispod visećih elemenata, ili je na zidovima.

Svijet vodenih snova - *Il Bagno*

Šum vode, miris drva i bilja protezao se duž dvaju paviljona posvećenih kupanju, čistoći, uživanju i opuštanju. Unatoč financijskoj krizi koja je proteklih godina oslabila brojne proizvođače i tržišta, sektor proizvodnje kupaoničkog namještaja nije previše osjetio recesiju. Kupaonice su zaista raskošnije nego ikada!

Slika 15. Noviteti na štandu tvrtke Elektrolux

Slika 16. Novi koncepti kuhinjskih uređaja i pratećih elemenata, tvrtka Nardi

Slika 17. Skulpture u kupaonici, kolekcija *Dry*, dizajn Enzo Berti, tvrtka Kreoo by Decormarmi

Slika 18. Novitet tvrtke Webert: umivaonik se odvaja od postolja, što olakšava održavanje.

Istraživanje novih materijala, ali i primjena starih u novome površinskom ruhu te nenadmašni oblici i konstrukcije vode konačnom cilju – ugodi i opuštanju u oazi čistih mirisnih snova. Napredak u kiparstvu pridonio je široj upotrebi prirodnog kamena, što se ogleda i na području kupaoničkog namještaja, s vrlo visokom kvalitetom završne obrade. Odličan je primjer tvrtka Kreoo (sl. 17). Dizajn i obrtništvo tako su spojeni u vrhunske proizvode, a sve je podržano najnovijim tehnologijama.

Budući da u kupaonici sve mora biti čisto, održavanje, čišćenje i pranje svih kupaoničkih elemenata nerijetko stvara glavobolje, osobito kada se sjetimo nepoželjnog kamenca. Da bi održavanje bilo ugoda, pobrinula se tvrtka Webert, koja je ove godine prikazala novi koncept pomičnog umivaonika, koji se jednostavnim podizanjem odvaja od postolja i tako lakše održava i čisti (sl. 18).

Radijatori su, kao i prije dvije godine, po oblikovnoj skulpturalnosti nadmašili sami sebe. Neobična rješenja radijatora koja postaju funkcionalan ukras u prostoru pokazala je i tvrtka Deltacolor iz Italije (sl. 19).

Salone Satellite

Salone Satelite je, kao i svake godine, bio posvećen mladim dizajnerskim nadama, mlađim od 35 godina te je privukao pozornost brojnih proizvođača, a ove je godine u dva paviljona ugostio mnoge profesionalne dizajnere i fakultete dizajna iz cijelog svijeta. Okupio je, prema podacima Press centra, oko 750 najperspektivnijih međunarodnih mladih dizajnera, nudeći im mogućnost suradnje s proizvođačima. Ta izložba uvijek nastoji biti orijentirana prema budućnosti, a ove je godine imala temu *Dizajn<->Tehnologija.* Sukladno osnovnoj temi, prikazana je i glavna instalacija na izložbi koja je objedinila 15 interpretacija, rad 15 dizajnera- bivših i sadašnjih predstavnika *Salone Satellite* (sl. 20).

Slika 19. Funkcionalna skulpturalnost radijatora tvrtke Deltacolor

Slika 20. Instalacija police u obliku broja 15, s prikazanim najuspješnijim proizvodima posljednjih 15 godina *Salone Satellitea*

Slika 22. Izložbeni štand hrvatske dizajnerice Željke Kavran na *Salone Satelliteu*

Na *Salone Satellite* osobita se važnost pridaje kvaliteti obrazovanja pa su tradicionalno pozvane brojne škole iz cijelog svijeta. Ove se godine odazvalo 17 dizajnerskih škola, od kojih su neke sudjelovale prvi put. To su: American University of Sharjah, Ujedinjeni Arapski Emirati; Art Future design School iz Rusije; Centro de Investigaciones de Diseño Industrial iz Meksika; Central Academy of Fine Arts, Kina; Enaip-CSF, Italija; Hanseo University, Koreja; Istituto Europeo di Design, Španjolska; Kanazawa College of Art, Japan; New York Institute of Technology, SAD; Politecnico di Milano, Italija; PUC-Pontificia Universidade do Rio de Janeiro, Brazil; Ss. Cyril and Methodius University, Makedonija; Technical School Wood Art, Srbija; Universidad Piloto de Colombia, Kolumbija; Hochschule Darmstadt, Njemačka te University of Cambridge iz Velike Britanije.

Slika 21. Atmosfera na *Salone Satelliteu*

Na svim stazama za hodanje i na svim izložbenim štandovima vladala je neformalna i ležerna atmosfera (sl. 21), na kojima su izlagači – dizajneri studenti i profesionalci objašnjavali vlastite ideje i koncepte.

Na *Salone Satelliteu* i ove je godine, kao i prethodne, uspješno sudjelovala naša dizajnerica Željka Kavran iz Čakovca. Postav njezinih izložaka i izgled štanda prikazan je na slici 22. Čestitamo i nadamo se da ćemo je vidjeti i sljedeće godine s novim uradcima!

Dizajnerski događaji izvan *I Salone*

Svijet suvremenog dizajna na rubu je promjena i više je usmjeren na prikaze koncepata i dizajnerskih procesa nego na prezentacije gotovih proizvoda. Takav pristup pomalo zbunjuje svakodnevni svijet i gledatelje koji su navikli godinama promatrati gotove proizvode uzimajući ih „zdravo za gotovo“, bez razmišljanja. Današnji dizajn ima potpuno drugačiji pristup. On uvlači promatrača u svoj svijet, prisiljava ga na aktivno sudjelovanje i doživljavanje svih predmeta koji u konačnici uopće ne moraju biti dovršeni („gotovi“). Naprotiv, korisnik sam dovršava i oblikuje proizvod prema vlastitim potrebama, koristeći se svim osjetima i temeljeći se na započetom konceptu ili procesu stvaranja. Današnji dizajn jednostavno prisiljava na nov način promatranja okruženja, traži sudjelovanje, snažnu svjestnost, otvorenost i percepciju promatrača.

Dizajnerska zona *Ventura Lambrate* uzbudljiv je i sve utjecajniji događaj u sklopu *Milano Design Weeka*. To je rastuća i dinamična platforma na kojoj se predstavljaju već etablirani, ali i najnoviji dizajnerski brendovi, poznati autori i novi talenti, galerije i institucije s područja dizajna iz Europe i svijeta. Organizatori tog projekta, nizozemska inicijativa Organisation in Design, pokrenuli su ga kao svojevrsno proširenje *Design Weeka* / *Salone del Mobile*, koje je oživjelo indu-

Slika 23. Atmosfera u zoni *Ventura Lambrate*

Slika 24. Atmosfera u zoni *Tortone*

strijsku zonu grada, ali i potaknulo novo zanimanje profesionalaca, novinara i javnosti za suvremenu dizajnersku produkciju. O utjecaju projekta *Ventura Lambrate* govori i činjenica da se u protekle tri godine iz Milana i Italije proširio i na Berlin, a uskoro će osvojiti i Belgiju.

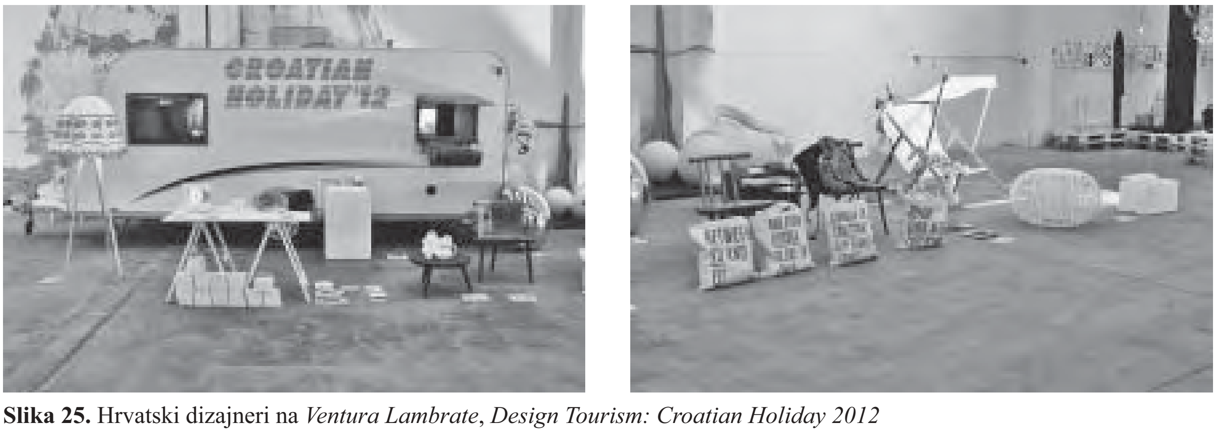
Organizatori događaja na *Ventura Lambrate 2012* prikupili su proizvode koji prikazuju i analiziraju različite promjene i koncepte, jer je misao vodilja *Venture Lambrate* upravo eksperiment, kreativnost i prednost sadržaja pred formom. Novi prikazani koncepti bude iz sna zaboravljene tehnike ili osmišljavaju inventivne procese izrade koji omogućuju neograničenu paletu novih proizvoda.

Pokazatelje uspješnosti samog događaja potvrđuju i ovogodišnji brojevi: *Ventura Lambrate* spojila je 90 izložbi i jedan posebni projekt, iz 33 države svijeta. Izložba je postavljena na više od 13 000 m², a na njoj je sudjelovalo ukupno više od 600 dizajnera te ju je razgledalo više od 60 00 posjetitelja i više od tisuću registriranih novinara.

Uz *Ventura Lambrate* svakako treba izdvojiti i zonu *Tortone,* koja je okupila brojne profesionalne dizajnere i već etablirane tvrtke u području dizajna te proizvodnje namještaja i prateće opreme.

Ipak, sve navedeno možda pomaže u sagledavanju veličine i važnosti navedenih događaja, no nikako nije dostatno za izražavanje svih dojmova i nakupljene energije koju jednostavno svatko mora sam doživjeti kako bi se uvjerio u snagu izloženoga. Dakle, nema vam druge, već iduće godine dođite, vidite, dotaknite i osjetite! Atmosfera s *Ventura Lambrate* i *Tortone* prikazana je slikama 23. i 24.

U sklopu *Ventura Lambrate* predstavljena je izložba *Design Tourism: Croatian Holiday 2012* (sl. 25). Da bi bilo jasnije značenje ovogodišnjeg sudjelovanja hrvatskih dizajnera na *Venturi Lambrate*, valja reći i nešto više o projektu. Kako se navodi na stranicama HDD-a, „projekt Design Tourism i njegovu prvu izložbenu fazu Croatian Holiday 2012 organiziralo je Hrvatsko dizajnersko društvo, a kustosice projekta su Ivana Borovnjak i Roberta Bratović. Bazirana na natječaju, ali



Slika 25. Hrvatski dizajneri na *Ventura Lambrate*, *Design Tourism: Croatian Holiday 2012*

Slika 26. Torba *Tovar* dizajnerice Maje Mesić, proizvođača Galko, u sklopu izložbe *Design Tourism: Croatian Holiday 2012*

i uključivanju nekoliko zanimljivih već realiziranih proizvoda, izložba ima za glavni cilj pokrenuti raspravu na temu nužnosti povezivanja dizajna i turizma u zemlji, a dotiče se tema turističkog iskustva zemlje čija se ekonomija uvelike oslanja na tu gospodarsku granu, pitanja odnosa nasljeđa i suvremenosti, ponude i potrošnje identiteta, ali i sustavne strategije nasuprot stihijskom pristupu" (više na: http://dizajn.hr/#/1028-dizajn-turizam-proizvodi-hrvatskih-dizajnera-na-venturi-lambrate/). Radovi 15 hrvatskih dizajnera i dizajnerskih timova na duhovite, inteligentne i polemične načine tematiziraju vezu dizajna i turizma, njegovih klišeja, konvencija, identiteta i potencijala. Primjer je i proizvod simboličnog naziva *Tovar,* autorice Maje Mesić, proizvođača Galko (slika 26), koji spaja tradicionalne elemente i idealno ilustrira promijenu uloga u metaforičkom ali i funkcionalnom smislu. Tovar nije samo torba, već spoj praktičnosti, izdržljivosti, otpornosti i funkcionalnosti i, moramo priznati, dobro bi nam došao na sajmu za pohranu i nošenje svih kataloga, časopisa, knjiga i CD-ova prikupljenih na sajmu!

Za kraj…

Dojmovi s ovogodišnjeg posjeta Milanu

Proizvodi izloženi na *I Saloni 2012* pokazuju da svijet proizvodnje namještaja i opreme još osjeća recesiju i strah od neizvjesnoga, no ipak nije zapao u sivilo, naporotiv! Izlagači su dali sve od sebe kako bi se pokazali u punom sjaju, počevši od uređenja štadova i marketinške pripremljenosti, osobito samim izlošcima koje su prikazali. Nenadmašna kvaliteta, poznati talijanski dizajn i šarm, dosjetljivost i „priča" proizvoda, no ipak uz prisutan razum, bez većih iznenađenja, noviteta i inovacija u dizajnu i tehnologijama. Primjer koji ipak treba spomenuti možda je izuzetan, a autore je oduševio inventivnošću u masi spomenutoga. Odnosi se na mogućnost reciklaže postojećih drvenih elemnata u drugačijem kontekstu. Promišljanje i konceptualno istraživanje elemenata koji prvobitno čine dijelove bačve za pohranu vina, ulja ili nečega drugog odlično je iskorišten u projektu *Barrique- San Patrignano* za oblikovanje elemenata urbane opreme, sjedalica, klupa i drugih zanimljivih rješenja (sl. 27).

Ove su godine događaji organizirani izvan samog sajma, u središtu i industrijskim zonama Milana, nadmašili prethodne godine. Pozornost je pridana upravo mla-

Slika 27. Koncept prenamjene gradbenih drvnih elemenata u novu oblikovnu funkciju

dim kreativcima koji su svojim radom već počeli stjecati utjecaj na međunarodnom tržištu- dizajnerima i umjetnicima iz drugih područja, te studentima dizajna kao jamstvu daljnjeg razvoja i održanja kvalitete i dizajna.

Sve ovo bio je jasan pokazatelj kako talijanski smisao i duh usmjeren ka lijepome, uobličen i u *I Salone*, ima jasnu težnju biti svjetskim liderom na tom području, kako u sadašnjosti, tako i u budućnosti.

Autori predlažu: svakako planirajte posjet sljedećemu milanskom sajmu, no barem u trajanju od tri dana. Naša dva intenzivno provedena dana u tom gradu dizajna nikako nisu dostatna! Vidimo se u travnju 2013. godine u Milanu, kada *I Saloni* slavi 52. obljetnicu!

dr. sc. Danijela Domljan, magistrica dizajna
doc. dr. sc. Ivica Župčić
Ivan Littvay, dipl. ing.

Fotografije: Ivan Littvay, Danijela Domljan, Maja Mesić i Press *I Saloni*

Vochysia tomentosa DC

NAZIVI

Drvo botaničke vrste *Vochysia tomentosa* DC pripada porodici *Vochysiaceae*.

Trgovački naziv te vrste je quaruba (Brazil, Njemačka); caizeta, cedrorana, urucuca, vinheiro do matto (Brazil); emeri (Francuska, Velika Britanija); itebali, grignon fou, kougli (Gvajana); kwari, etaballi kwarie, wane kwarie (Surinam); tintin (Venezuela).

NALAZIŠTE

Drvo uspijeva u Srednjoj i Južnoj Americi, od Meksika do Perua, a najviše ga ima u Gvajani, Surinamu i Brazilu, gdje pretežno zauzima područja tropskih nizinskih kišnih šuma slijevnog područja Amazone.

STABLO

Stabla dosežu visinu od 25 do 40 metara. Dužina čistog debla je od 15 do 20 metara, srednjeg promjera debla od 50 do 80 centimetara. Debla su ravnoga i cilindričnog oblika. Kora stabla je tanka, glatka, ljušti se u velikim krpama.

DRVO

Makroskopska obilježja

Drvo *Vochysia tomentosa* DC jedričavo je, sa slabo uočljivim godovima. Srž mu je nešto tamnija od bjeljike, crvenkastoga, žućkastoga ili smeđeg tona. Bjeljika je pretežno široka, rjeđe uska, žućkastosiva. Prijelaz bjeljike u srž je postupan. Tekstura drva je pravilna, srednje gruba, bez sjaja. Žica drva uglavnom je ravna, rjeđe valovita. Na tangentnim ravninama često su uočljive duge i relativno široke pruge, koje čine aksijalni intercelularni kanali raspoređeni u tangentnim nizovima. Drvo je rastresito porozno. Pore i aksijalni parenhim vidljivi su običnim okom, a drvni su traci dobro uočljivi povećalom.

Mikroskopska obilježja

Aksijalne traheide duge su 1,70...2,40...3,80 milimetara. Traheje su raspoređene pojedinačno, rjeđe se pojavljuju u parovima ili u manjim skupinama. Promjer traheja iznosi 100...200...250 (300) mikrometara, a gustoća im je 1...2...3 na 1 mm^2 poprečnog presjeka. Volumni udio traheja kreće se oko 15 %. Traheje u srži neznatno su ispunjene tilama. Aksijalni parenhim paratrahealno je aliforman, konfluentan ili vrpčast.Volumni udio aksijalnog parenhima u građi drva iznosi oko 15 %.

Drvni su traci heterogeni, jednoredni ili višeredni, pretežno šestoredni, difuzno raspoređeni.

Visina jednorednih drvnih trakova iznosi 100... 320...570 mikrometara, a višerednih 630...580...1100 mikrometara. Gustoća jednorednih drvnih trakova je od 6 do 13 – 18 na 1 mm, a gustoća višerednih trakova od 1 do 2 – 4 na 1 mm. Volumni udio drvnih trakova iznosi oko 23 %.

Drvna su vlakanca libriformska, dugačka 1300...1600...2200 mikrometara. Dvostruka debljina staničnih stijenki vlakanaca iznosi 3,1...5,0...7,5 mikrometara, a promjer lumena 12,0...16,0...19,0 mikrometara. Volumni je udio vlakanaca oko 47 %.

Fizička svojstva

Gustoća standardno suhog drva, ρ_o	370...480 kg/m^3
Gustoća prosušenog drva, ρ_{12-15}	410...530 kg/m^3
Gustoća sirovog drva, ρ_s	1050...1070 kg/m^3
Poroznost	68...75 %
Radijalno utezanje, β_r	2,5...4,8 %
Tangentno utezanje, β_t	8,2...8,8 %
Volumno utezanje, β_v	10,8...13,7 %

Mehanička svojstva

Čvrstoća na tlak	(37) 40...48...70 MPa
Čvrstoća na vlak, paralelno s vlakancima	50...66...97 MPa
Čvrstoća na vlak, okomito na vlakanca	oko 2,0 MPa
Čvrstoća na savijanje	61...80...113 MPa
Tvrdoća (prema Brinellu), paralelno s vlakancima	oko 40 MPa
okomito na vlakanca	oko 20 MPa
Modul elastičnosti	8,0...11,0...14,0 GPa

TEHNOLOŠKA SVOJSTVA

Obradivost

Drvo se ručno i strojno dobro obrađuje, uz slabo do srednje zatupljivanje alata. Dobro se reže i ljušti. Pri blanjanju se čupaju vlakanca. Drvo dobro drži čavle i vijke. Dobro se lijepi i površinski obrađuje. Za postizanje visokoga površinskog sjaja drva pore je potrebno prethodno zapuniti.

Sušenje

Dobro se i brzo suši, no drvo pri sušenju često puca, vitoperi se ili se pojavljuje kolaps.

Trajnost i zaštita

Prema normi HRN 350-2, 2005, srž drva *Vochysia tomentosa* DC slabe je trajnosti (klasa 4) ili srednje trajnosti (klasa 3). Srž je slabo permeabilna za zaštitna sredstva.

Uporaba

Drvo *Vochysia tomentosa* DC upotrebljava se za izradu furnira, osobito ljuštenih, onih za furnirske ploče. Služi i kao konstrukcijsko građevno drvo lakih konstrukcija, i to samo za unutarnju ugradnju. Kao specijalno drvo upotrebljava se u brodogradnji i za izradu sanduka.

Sirovina

Drvo *Vochysia tomentosa* DC na tržištu se pojavljuje u obliku trupaca duljine 4 − 8 metara i duljih, srednjeg promjera 50 do 90 centimetara. Zbog slabe prirodne trajnosti transport sirovine do mjesta prerade mora se obaviti što brže.

Literatura

1. ***1980: Šumarska enciklopedija, Jugoslavenski leksikografski zavod, Zagreb.
2. H. G. Richter; M. J. Dallwitz, 2000: Commercial timbers: descriptions, illustrations, identification, and information retrieval. In English, French, German, and Spanish. Version: 4th May 2000. http://biodiversity.uno.edu/delta/.
3. HRN EN 350-2, 2005: Trajnost drva i proizvoda na osnovi drva – Prirodna trajnost masivnog drva.
4. Wagenführ, R.; Scheiber, C., 1974: HOLZATLAS, VEB Fachbuchverlag, Leipzig, 462-464.
5. ***1964:Wood dictionary, Elsevier publishing company, Amsterdam.

prof. dr. sc. Jelena Trajković
doc. dr. sc. Bogoslav Šefc

Upute autorima

Opće odredbe

Časopis *Drvna industrija* objavljuje znanstvene radove (izvorne znanstvene radove, pregledne radove, prethodna priopćenja), stručne radove, izlaganja sa savjetovanja, stručne obavijesti, bibliografske radove, preglede te ostale priloge s područja biologije, kemije, fizike i tehnologije drva, pulpe i papira te drvnih proizvoda, uključujući i proizvodnu, upravljačku i tržišnu problematiku u drvnoj industriji.

Predaja rukopisa podrazumijeva uvjet da rad nije već predan negdje drugdje radi objavljivanja ili da nije već objavljen (osim sažetka, dijelova objavljenih predavanja ili magistarskih radova odnosno disertacija, što mora biti navedeno u napomeni) te da su objavljivanje odobrili svi suautori (ako rad ima više autora) i ovlaštene osobe ustanove u kojoj je istraživanje provedeno. Kad je rad prihvaćen za objavljivanje, autori pristaju na automatsko prenošenje izdavačkih prava na izdavača te na zabranu da rad bude objavljen bilo gdje drugdje ili na drugom jeziku bez odobrenja nositelja izdavačkih prava.

Znanstveni i stručni radovi objavljuju se na hrvatskome, uz sažetak na engleskome, ili se pak rad objavljuje na engleskome, sa sažetkom na hrvatskom jeziku. Naslov, podnaslovi i svi važni rezultati trebaju biti napisani dvojezično. Ostali se članci uglavnom objavljuju na hrvatskome. Uredništvo osigurava inozemnim autorima prijevod na hrvatski. Znanstveni i stručni radovi podliježu temeljitoj recenziji najmanje dvaju recenzenata. Izbor recenzenata i odluku o klasifikaciji i prihvaćanju članka (prema preporukama recenzenata) donosi Urednički odbor.

Svi prilozi podvrgavaju se jezičnoj obradi. Urednici će od autora zahtijevati da tekst prilagode preporukama recenzenata i lektora, te zadržavaju i pravo da predlože skraćivanje ili poboljšanje teksta. Autori su potpuno odgovorni za svoje priloge. Podrazumijeva se da je autor pribavio dozvolu za objavljivanje dijelova teksta što su već negdje objavljeni te da objavljivanje članka ne ugrožava prava pojedinca ili pravne osobe. Radovi moraju izvještavati o istinitim znanstvenim ili tehničkim postignućima. Autori su odgovorni za terminološku i metrološku usklađenost svojih priloga. Radovi se šalju elektroničkom poštom na adresu:

drind@sumfak.hr ili techdi@sumfak.hr

Upute

Predani radovi smiju sadržavati najviše 15 jednostrano pisanih A4 listova s dvostrukim proredom (30 redaka na stranici), uključujući i tablice, slike te popis literature, dodatke i ostale priloge. Dulje je članke preporučljivo podijeliti na dva ili više nastavaka. Tekst treba biti u *doc formatu*, u potpunosti napisan fontom *Times New Roman* (tekst, grafikoni i slike), normalnim stilom, bez dodatnog uređenja teksta.

Prva stranica poslanog rada treba sadržavati puni naslov, ime(na) i prezime(na) autora, podatke o zaposlenju autora (ustanova, grad i država) te sažetak s ključnim riječima (duljina sažetka približno 1/2 stranice A4).

Posljednja stranica treba sadržavati titule, zanimanje, zvanje i adresu (svakog) autora, s naznakom osobe s kojom će Uredništvo biti u vezi.

Znanstveni i stručni radovi moraju biti sažeti i precizni. Osnovna poglavlja trebaju biti označena odgovarajućim podnaslovima. Napomene se ispisuju na dnu pripadajuće stranice, a obrojčavaju se susljedno. One koje se odnose na naslov označuju se zvjezdicom, a ostale uzdignutim arapskim brojkama. Napomene koje se odnose na tablice pišu se ispod tablica, a označavaju se uzdignutim malim pisanim slovima, abecednim redom.

Latinska imena trebaju biti pisana kosim slovima (italicom), a ako je cijeli tekst pisan kosim slovima, latinska imena trebaju biti podcrtana.

U uvodu treba definirati problem i, koliko je moguće, predočiti granice postojećih spoznaja, tako da se čitateljima koji se ne bave područjem o kojemu je riječ omogući razumijevanje ciljeva rada.

Materijal i metode trebaju biti što preciznije opisane da omoguće drugim znanstvenicima ponavljanje pokusa. Glavni eksperimentalni podaci trebaju biti dvojezično navedeni.

Rezultati trebaju obuhvatiti samo materijal koji se izravno odnosi na predmet. Obvezatna je primjena metričkog sustava. Preporučuje se upotreba SI jedinica. Rjeđe rabljene fizikalne vrijednosti, simboli i jedinice trebaju biti objašnjeni pri njihovu prvom spominjanju u tekstu. Za pisanje formula valja se koristiti Equation Editorom (programom za pisanje formula u MS Wordu). Jedinice se pišu normalnim (uspravnim) slovima, a fizikalni simboli i faktori kosima (italicom). Formule se susljedno obrojčavaju arapskim brojkama u zagradama, npr. (1) na kraju retka.

Broj slika mora biti ograničen samo na one koje su prijeko potrebne za objašnjenje teksta. Isti podaci ne smiju biti navedeni i u tablici i na slici. Slike i tablice trebaju biti zasebno obrojčane, arapskim brojkama, a u tekstu se na njih upućuje jasnim naznakama ("tablica 1" ili "slika 1"). Naslovi, zaglavlja, legende i sav ostali tekst u slikama i tablicama treba biti napisan hrvatskim i engleskim jezikom.

Slike je potrebno rasporediti na odgovarajuća mjesta u tekstu, trebaju biti izrađene u rezoluciji 600 dpi, crno-bijele (objavljivanje slika u koloru moguće je na zahtjev autora i uz posebno plaćanje), formata jpg ili tiff, potpune i jasno razumljive bez pozivanja na tekst priloga.

Svi grafikoni i tablice izrađuju se kao crno-bijeli prilozi (osim na zahtjev, uz plaćanje). Tablice i grafikoni trebaju biti na svojim mjestima u tekstu te originalnog formata u kojemu su izrađeni radi naknadnog ubacivanja hrvatskog prijevoda. Ako ne postoji mogućnost za to, potrebno je poslati originalne dokumente u formatu u kojemu su napravljeni (*excel* ili *statistica* format).

Naslovi slika i crteža ne pišu se velikim tiskanim slovima. Crteži i grafikoni trebaju odgovarati stilu časopisa (fontovima i izgledu). Slova i brojke moraju biti dovoljno veliki da budu lako čitljivi nakon smanjenja širine slike ili tablice. Fotomikrografije moraju imati naznaku uvećanja, poželjno u mikrometrima. Uvećanje može biti dodatno naznačeno na kraju naslova slike, npr. "uvećanje 7500 : l".

Diskusija i zaključak mogu, ako autori žele, biti spojeni u jedan odjeljak. U tom tekstu treba objasniti rezultate s obzirom na problem postavljen u uvodu i u odnosu prema odgovarajućim zapažanjima autora ili drugih istraživača. Valja izbjegavati ponavljanje podataka već iznesenih u odjeljku *Rezultati*. Mogu se razmotriti naznake za daljnja istraživanja ili primjenu. Ako su rezultati i diskusija spojeni u isti odjeljak, zaključke je nužno napisati izdvojeno. Zahvale se navode na kraju rukopisa. Odgovarajuću literaturu treba citirati u tekstu, i to prema harvardskom sustavu (*ime – godina*), npr. (Bađun, 1965). Nadalje, bibliografija mora biti navedena na kraju teksta, i to abecednim redom prezimena autora, s naslovima i potpunim navodima bibliografskih referenci. Popis literature mora biti selektivan, a svaka referenca na kraju mora imati naveden DOI broj, ako ga posjeduje (http://www.doi.org) (provjeriti na http://www.crossref.org).

Primjeri navođenja literature

Članci u časopisima: Prezime autora, inicijal(i) osobnog imena, godina: Naslov. Naziv časopisa, godište (ev. broj): stranice (od – do). Doi broj.

Primjer

Kärki, T., 2001: Variation of wood density and shrinkage in European aspen (*Populus tremula*). Holz als Roh- und Werkstoff, 59: 79-84. http://dx.doi.org/10.1007/s001070050479.

Knjige: Prezime autora, inicijal(i) osobnog imena, godina: Naslov. (ev. izdavač/editor): izdanje (ev. svezak). Mjesto izdanja, izdavač (ev. stranice od – do).

Primjeri

Krpan, J., 1970: Tehnologija furnira i ploča. Drugo izdanje. Zagreb, Tehnička knjiga.

Wilson, J. W.; Wellwood, R. W., 1965: Intra-increment chemical properties of certain western Canadian coniferous species. U: W. A. Cote, Jr. (Ed.): Cellular Ultrastructure of Woody Plants. Syracuse, N.Y., Syracuse Univ. Press, pp. 551- 559.

Ostale publikacije (brošure, studije itd.)

Müller, D., 1977: Beitrag zür Klassifizierung asiatischer Baumarten. Mitteilung der Bundesforschungsanstalt für Forstund Holzvvirt schaft Hamburg, Nr. 98. Hamburg: M. Wiederbusch.

Web stranice

***1997: "Guide to Punctuation" (online), University of Sussex, www.informatics.sussex.ac.uk/department/docs/punctuation/node00.html. First published 1997 (pristupljeno 27. siječnja 2010).

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Latin names shall be printed in italics and underlined.

Introduction should define the problem and if possible the framework of existing knowledge, to ensure that readers not working in that particular field are able to understand author’s intentions.

Materials and methods should be as precise as possible to enable other scientists to repeat the experiment. The main experimental data should be presented bilingually.

The results should involve only material pertinent to the subject. The metric system shall be used. SI units are recommended. Rarely used physical values, symbols and units should be explained at their first appearance in the text. Formulas should be written by using Equation Editor (program for writing formulas in MS Word). Units shall be written in normal (upright) letters, physical symbols and factors in italics. Formulas shall be consecutively numbered with Arabic numerals in parenthesis (e.g. (1)) at the end of the line.

The number of figures shall be limited to those absolutely necessary for clarification of the text. The same information must not be presented in both a table and a figure. Figures and tables should be numbered separately with Arabic numerals, and should be referred to in the text with clear remarks (“Table 1” or “Figure 1”). Titles, headings, legends and all the other text in figures and tables should be written in both Croatian and English.

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Journal articles: Author’s second name, initial(s) of the first name, year: Title. Journal name, volume (ev. issue): pages (from - to). DOI number.

Example:
Kärki, T., 2001: Variation of wood density and shrinkage in European aspen (*Populus tremula*). Holz als Roh- und Werkstoff, 59: 79-84. http://dx.doi.org/10.1007/s001070050479.

Books:
Author’s second name, initial(s) of the first name, year: Title. (ev. Publisher/editor): edition, (ev. volume). Place of publishing, publisher (ev. pages from - to).

Examples:
Krpan, J. 1970: Tehnologija furnira i ploča. Drugo izdanje. Zagreb: Tehnička knjiga.
Wilson, J.W.; Wellwood, R.W. 1965: Intra-increment chemical properties of certain western Canadian coniferous species. U: W. A. Cote, Jr. (Ed.): Cellular Ultrastructure of Woody Plants. Syracuse, N.Y., Syracuse Univ. Press, pp. 551-559.

Other publications (brochures, studies, etc.):
Müller, D. 1977: Beitrag zur Klassifizierung asiatischer Baumarten. Mitteilung der Bundesforschungsanslalt für Forst- und Holzwirtschaft Hamburg, Nr. 98. Hamburg: M. Wiederbusch.

Websites:
***1997: “Guide to Punctuation” (online), University of Sussex, www.informatics.sussex.ac.uk/department/docs/punctuation/node00.html. First published 1997 (Accessed Jan. 27, 2010).

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