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PROPERTIES OF THERMALLY MODIFIED WOOD IN OIL

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Abstract

The existence of life on earth is possible if stored and sustainable develop our surroundings in this and fauna in the forest which occupies the most significant portion. That is why it is vital to use reasonable wood resources and their processing to use environmentally friendly technologies. Thermally wood modification is green technology, like alternative of chemical modification, which damage environment. This technology increase exploitation life of wooden element, because received wood has increase fungus resistance, reduced hygroscopicity and improved dimensional stability [1;2;4;6;7;8;13]. There are four methods for thermally modification of timber: heat treatment in a humid environment; heat treatment in an inert gas; heat treatment in a hot press; heat treatment in oil. Based on these methods have been developed and implemented in four production technologies: Finnish technologies; [Syrjänen 2001]; French technologies [Vernois 2001]; Neiderland technologies (plato process) [Militz and Tjeerdsma: 2001]; German technology [Rapp and Sailer: 2001]. It was found that due to thermal modification of wood of pine radiant in an environment of linseed oil improves dimensional stability and resistance to decay due to the decreased hygroscopicity, but reducing the mechanical performance [Dubey, MK: 2010] . It has been found by other investigators [Rapp, A.O., M. Sailer:2001; Bazyar,B.:2012; Welzbacher, C. R., A.O. Rapp, P. Haller, J. Wehsener:2005]. Properties of thermally modified timber of many species tree are being actively studied in.different countries [6;17;18;19;20;21;22]. The results of these researches are presented in many papers, whereas the Bulgarian production it is still poorly known (Panayotov,P.A. and Georgiev, Zh.: 2013). In this study, timber of three species tree (spruce, beech and poplar) was modified in sunflower oil till temperature 210°C.

Key words: *thermo wood, spruce timber, beech timber, poplar timber, properties, sunflower.*

MATERIALS AND METHODS

About thermally modification of wood are selected three tree species having industrial importance for the Republic of Bulgaria: spruce, poplar and beech. In Fig. 1 is present heat treatment plan in which it is obtained modified wood in double refined sunflower oil (oil). The search was conducted in 8 different series of modified and untreated wood: spruce (Picea abies L.), beech (Fagus sylvatica L.) and poplar (Populus alba L.). Series are indexed so that the first index to indicate the type of wood as follows: spruce -S; poplar -P; beech -F. The series included 16 samples with dimensions: 30x30x10 mm (last one in longitudinal direction) according to BDS 16987-89. Untreated wood is dried to constant weight in kiln SHT 200 at 103 ± 2°C, they are indexed by a second index "N". Modification was carried out in a certain temperature regime at different processing environment: sunflower oil and glycerol. The series produced in a medium of sunflower oil are marked with a second index S.

The received thermally modified wood is tested physically and mechanical properties: water vapour sorption, water sorption, swelling, ASE, density, static hardness, static bending strength, impact strength, ultimate strength in compression parallel to the grains, shear strength parallel to the grains, splitting strength. To establish the parameter values of these properties using appropriate size , structure and size specimens and methods in the Bulgarian, European and international standards such as : BDS 16987-89 , BS EN 844:1994; BS EN384: 2004 , BS EN 408:2004 , BS ISO 9086-1:1994; BS ISO 3131:1999. To determine the sorption of selected specimens are placed over supersaturate solution of NaCl in water 60 days according to BDS 16987-89 and weighed on day 1,2,3,5,8,13,20,30,40,50,60 analytical balance with tolerance 0.001 g. The moisture content is determined for each measurement by the following formula (1):

$$M_w = \frac{M_т - M_н}{M_н} 100, \% \qquad (1)$$

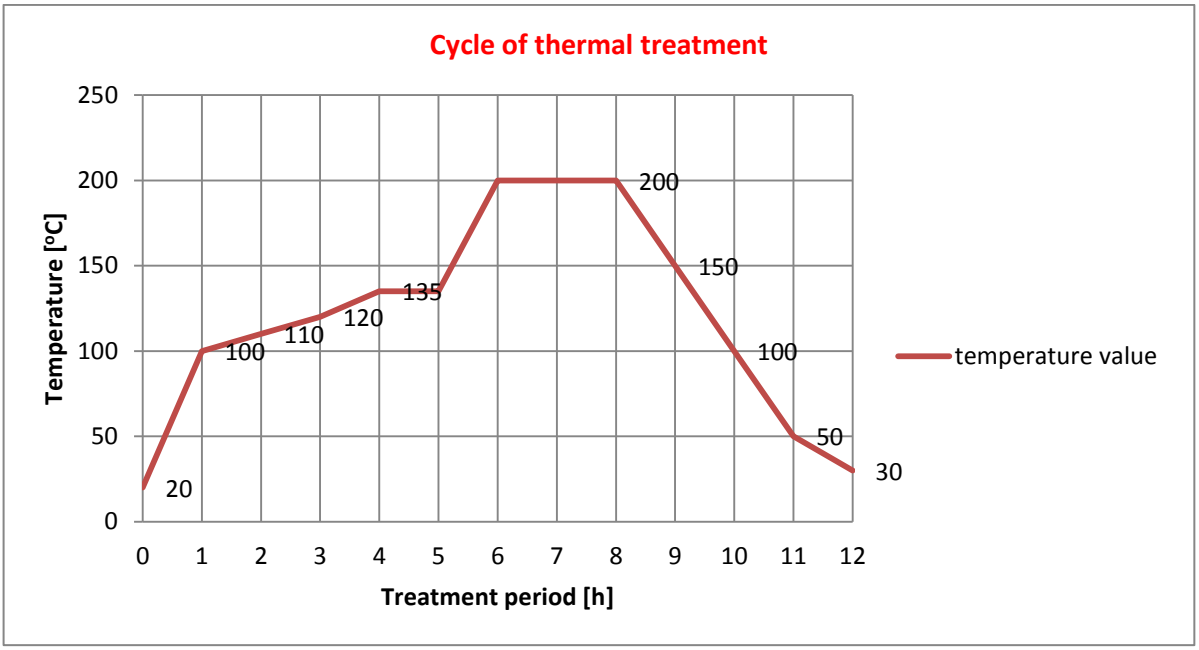


Fig.1. Heat treatment plan

The received thermally modified wood is tested physically and mechanical properties: water vapour sorption, water sorption, swelling, ASE, density, static hardness, static bending strength, impact strength, ultimate strength in compression parallel to the grains, shear strength parallel to the grains, splitting strength. To establish the parameter values of these properties using appropriate size , structure and size specimens and methods in the Bulgarian, European and international standards such as : BDS 16987-89 , BS EN 844:1994; BS EN384: 2004 , BS EN 408:2004 , BS ISO 9086-1:1994; BS ISO 3131:1999. To determine the sorption of selected specimens are placed over supersaturate solution of NaCl in water 60 days according to BDS 16987-89 and weighed on day 1,2,3,5,8,13,20,30,40,50,60 analytical balance with tolerance 0.001 g. The moisture content is determined for each measurement by the following formula (1):

$$M_w = \frac{M_T - M_H}{M_H} 100, \% \qquad (1)$$

where:

M_w is water content %; M_T is current mass; M_H is initial mass.

The kinetic of water vapour sorption is determinate on average values about each series.

Static hardness was determined by Brinell method on samples with dimensions 50x50x50 mm, diameter of ball is 10 mm, as in the formula for calculating take the diameter of the footprint. Load is performed with 1500 N, ie used is the following formula (2):

$$H_B = \frac{F}{S} = \frac{2.F}{\pi.D(D - \sqrt{D^2 - d^2})}, N/mm^2 \qquad (2)$$

where: F is the tensile force in N; S is the diameter of footprint, which is a spherical segment; D is the diameter of the pellet loading /10 mm/; d is the diameter of the impression in mm; π = 3.14. Load 1500 N accepts the formula expression (3)

$$H_B = \frac{95.5}{D - \sqrt{D^2 - d^2}}, N/mm^2 \qquad (3)$$

Loading is occurred slowly over 15 s. The maximum load is held for 30 s. Unloading is performed too slowly over the course also 15 s. Loading occurs in the middle of the cubic body over on all sides / two tangential and two radial , two front / having taken the average of the two measurements. In case used 20 samples with cubic form with measures 50x50x50 mm. for each series. Compressive strength parallel to the grains is determined on 16 samples of each variant with measurement 10x10x20 mm, (last one in longitudinal direction) according to BS 16987: 1989. Static bending strength is determined on 16 samples of each variant with measure 10x10x150 mm, (last one in longitudinal direction) according to BS 16987:1989. Shear strength along the grains is determined on 16 samples of each variant with measurement 20x30x50 mm, (last one in longitudinal direction) according to BS 16987:1989. Splitting strength is determined on 16 samples of each variant with measurement 20x20x50 mm, (last one in longitudinal direction) according to BS 16987:1989. Impact strength in bending is determined on 16 samples of each variant with measurement 10x10x50 mm, (last one in longitudinal direction) according to DIN. The test is performed with a supply of energy to the pendulum of 150 J. The consummated energy for the destruction of the test samples is measured with tolerance of 1 J.

The needed for this search about fungus resistance are made samples from received wood, with measurements 15x25x50 mm (last one in longitudinal direction) according to DIN EN 113. For each variant are made 24 samples. Fungus resistance is defined towards Poria placenta (Fr.) 125 a EbW and Coniophora puteana (Fr.) Karst., which caused brown rot on maltagarmedium (4% malt and 2% agar) in cultural flasks. Before installation in flasks modified samples are heated on 150 °C till constant weight with object to eliminate the part of soaked in wood oil. The samples are measured after cooling in exicator with calcium dichloride to determinate the absolute dry mass. After drying the samples are conditioned to air dry state in exicator with supersaturate solution of sodium chloride (relative air humidity 65%). The wet samples are installed in cultural flasks on fungus spawns. The exposure of samples on fungus spawns is for 120 days by temperature 22-24 °C, air humidity 80-90% and indirectly light. After that the samples are cleaned from spawns and weight to determinate the water content. It is determinate by formula (1):

$$W = \frac{M_2 - M_1}{M_1}.100,\% \qquad (1)$$

where: M_1 *is a mass of sample in air dry condition before installation;*

M_2 *is a mass after exposure in cultural flasks, cleaned of fungus spawns.*

After exposure the samples are dried in chamber by temperature 103±2 ºC till constant mass, after that they are cooling in exicator with calcium dichloride and weight to determinate the absolutely dry mass. The wood destruction is marked with mass loss, determinate by formula (2):

$$_{\Delta}M = \frac{M_o - M_3}{M_0}.100,\% \qquad (2)$$

where: M_0 *is initial absolutely dry mass before exposure;*

M_3 *is final mass after exposure, cleaned of fungus spawns and dried to absolutely dry mass.*

RESULTS AND ANALISYS

The received results about searched properties are present in tables and graphics. The density is defined on two different type samples: samples with measurement10x10x15 mm about compressive strength parallel to the grains and samples with measurement 50x50x50 mm about Brinell hardness test. The measurements are conduct after modification, drying in kiln at temperature 103±2ºC till constant weight and conditioned for 30 days till equilibrium water content. The results are present in Tabl.1 and Tabl.2. The analysis of results is that, thermally treatment in liquid heat medium increase density for all three wood types, because the medium remain in cell gaps. The spruce wood increase of density is at least (from 423 kg/m³ to 570 kg/m³) and considerably greater is the increase of the density of the beech wood (from 715 kg/m³ to 1082 kg/m³). The greatest increase is in the density of poplar wood (from 419 kg/m³ to 1013 kg/m³). The differences are statistically significant, as the coefficient of Student have values above 3. The difference of 367 kg/m³ density between natural and modified

beech wood is reliable as Student coefficient has a value of 75.2. This refers to the data presented in tabl.1. Density values defined for compressive strength parallel to the grains samples are present in Fig 2.

Tabl. 1. Density of untreated and thermally modified in oil wood on certain samples for testing compressive strength in parallel to the grains

Index	Standard deviation indicator					Water content %
	Aver. kg/m³	St.Dev. kg/m³	Ser kg/m³	Var %	p %	
FN	715	31.21	7.80	4.36	1.09	7.8
FS	1082	23.78	5.95	2.19	0.55	2.2
PN	419	15.48	3.87	3.69	0.92	8.5
PS	1013	25.49	6.37	2.52	0.62	2.1
SN	423	18.98	4.74	4.48	1.12	8.5
SS	570	21.34	5.34	3.74	0.93	4.8

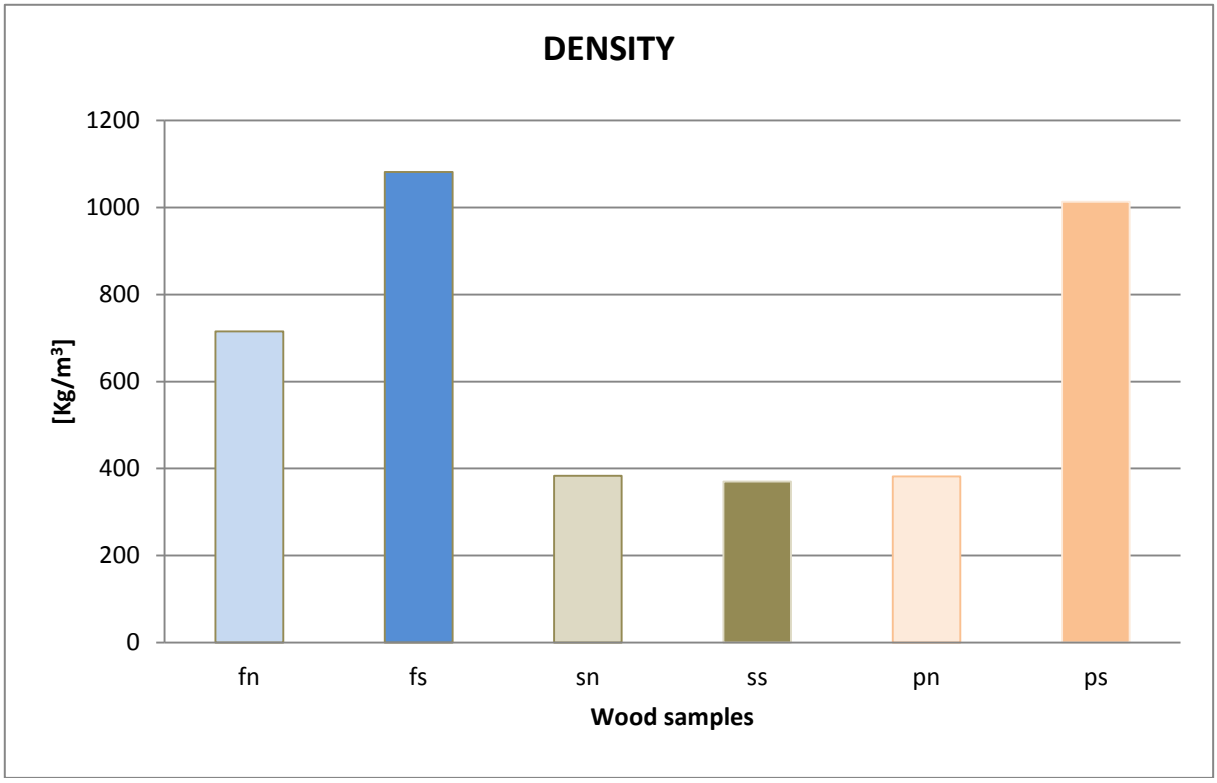


Fig. 2. Density of untreated and heat treated wood in oil.

The received results show that a lot of oil is remaining in wood after treatment. This samples are dried by temperature 170±10 ºC in period of 21 hours (3x7 = 21 hours) to take out remaining oil quantity after heat

treatment. After drying the samples are conditioned in temperature 20ºC and relative air humidity 55-65 % for a month before measure and tests. In the table have a good sight, that density increase after treatment. The highest density has modified beech: 1062 kg/m³. The standard deviation differences are reliable, because the coefficients of Student are higher than 3. The difference between density of untreated and modified beech from 367 kg/m³ is reliable. The spruce wood samples have lowest density increase (SS). It is density difference of 147 kg/m³, which is reliable with Student's coefficient of 9.54. The density difference between untreated and modified poplar wood (594 kg/m³) is reliable with Student's coefficient value of 114.9. Therefore oil is remain in wood after treatment and conditioned. It is a positive result about exploitation sometimes, but in other cases is not. In these cases this remaining quantity must be uptake of wood with final vacuum or other methods.

Tabl.2. Density of untreated and thermally modified in oil wood defined on Brinell test samples

Index	Standard deviation indicators					Water content
	Aver., kg/m³	Stand.Dev. kg/m³	Ser kg/m³	Var %	p %	%
FN	735.06	8.65	2.16	1.78	0.29	7.4
FS	861.56	20.41	5.10	2.37	0.59	1.9
PN	375.56	14.39	3.59	14.5	3.62	8.1
PS	736.38	22.26	5.57	3.02	0.75	1.9
SN	410.93	16.99	4.25	4.14	1.03	8.5
SS	441.94	15.38	3.84	3.47	0.86	5.2

In Tabl.3 and Fig.3 are present kinetic of water vapour sorption for a period of 60 days, according to BDS 16987-89.

Tabl. 3. Water vapour sorption for period of 60 days

Index	**Den-sity kg/m³**	**Water vapour sorption, %**										
		Time, d										
		1	**2**	**3**	**5**	**8**	**13**	**20**	**30**	**40**	**50**	**60**
PS	1013	0.72	0.83	0.91	0.93	0.99	1.04	1.08	1.18	1.35	1.43	1.54
PN	382	3.6	4.16	4.19	4.6	4.74	5.13	6.16	6.63	6.91	7.67	8.07
PG		3.17	4.3	5.16	6.49	7.47	9.08	10.17	12.26	13.41	14.7	15.17
FN	715	3.55	4.02	4.33	4.64	4.76	5.18	5.81	6.35	6.7	6.98	7.38
FS	1082	0.79	0.92	0.98	0.98	1.04	1.09	1.23	1.37	1.51	1.67	1.76
SS	382	3.16	3.14	3.1	3.25	3.37	3.58	3.86	4.03	4.56	4.83	5.18
SG		6.38	6.32	6.12	6.79	7.46	8.47	9.82	11.65	12.83	13.11	13.71
SN	370	5.06	5.42	5.43	5.77	5.81	6.44	6.82	7.53	8.08	8.26	8.44

From received results about water vapour sorption of heat treated wood, it can make some conclusions. The first and most important thing is heat medium agent which remains in wood after processes, change wood

hygroscopicity. When it is sunflower oil it has positive influence about reducing water vapour absorption, but when it is glycerol it is negative. The second aspect is wood spies and this study presents that the treatment effect is lower about spruce wood in comparison with beech and poplar wood. The cell walls structure of the spruce wood, prevent maximum sorption in depth of wood and this decrease the effect of treatment .The most important mechanical properties of thermally modified wood are present in graphics and tables. They are: static hardness; compressive strength parallel to the grains; sharing strength; splitting strength.The received average values about static hardness are present in tabl.4. The analysis or results is that the hardness values parallel to the grains are higher than tangential and radial and wood thermally modification in oil reduce Brinell hardness in all direction. This tendencies are established by other authors [4; 11; 20]. This reduction is not too vastly and is a result of remaining oil in wood. For example, beech wood hardness in longitudinal direction reduces from 97.43 N/mm² to 93.67 N/mm². In poplar and spruce wood tendencies are same, from 78.29 N/mm² to 71.67 N/mm² and from 62.85 N/mm² to 60.35 N/mm². It depends of the remaining in wood oil. Spruce wood has least quantity therefore hardness reduction after modification is less.

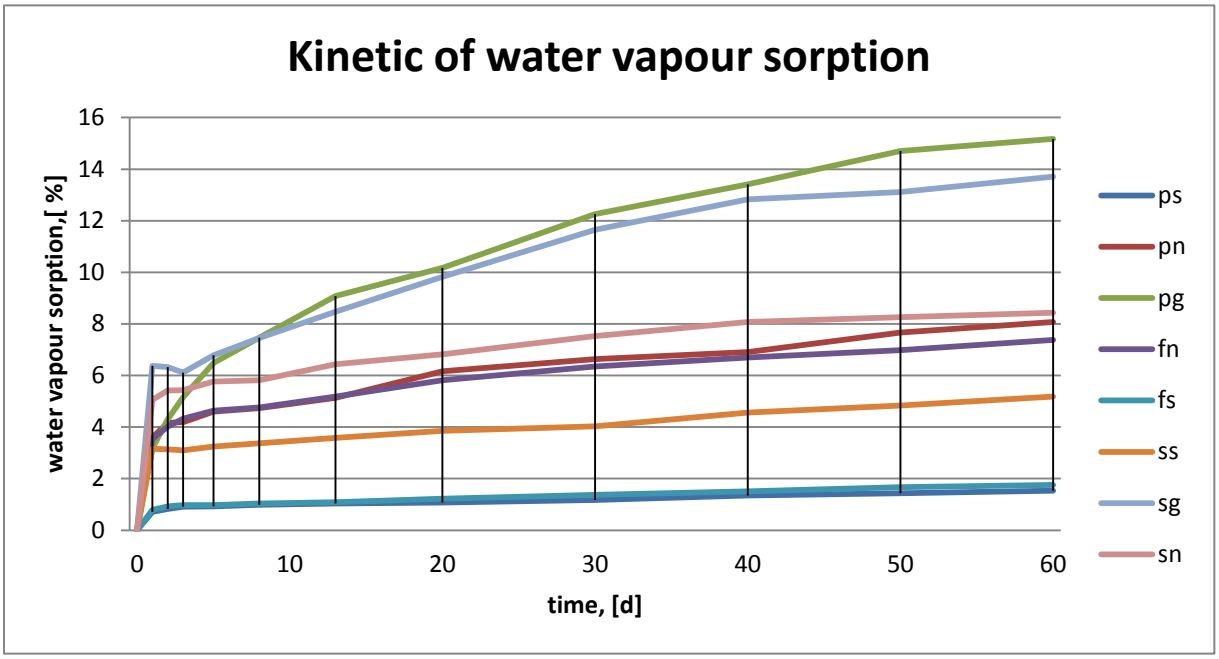


Fig.3. Graphic of kinetic of water vapour sorption of untreated and heat treated wood samples in oil and glycerol.

Tabl.4. Average values about Brinell hardness

N	Wood type	Index	Brinell hardness(HB), N/mm²		
			R	T	L
1	Beech untreated	FN	89.29	86.85	97.43
2	Beech modified in oil	FS	83.67	77.67	93.67
3	Poplar untreated	PN	65.29	62.85	78.29
4	Poplar modified in oil	PS	63.29	62.65	71.67
5	Spruce untreated	SN	55.37	51.64	62.85
6	Spruce modified in oil	SS	54.59	50.46	60.35

The received results about compressive strength parallel to the grains are standard deviated and present in tabl.5. Compressive strength parallel to the grains has reduced values after heat treatment in oil, but the differences are

not statistically proved. It is well marked in Fig.4. In tabl. 6 are presented average values of the bending strength. The results shows that thermally treated wood have lower values about bending strength. For example about beech this decrease of bending strength is 30 % in radial and 40% in tangential direction. The results are reliable; because Student coefficient has values more of 3.

Tabl.5. Compressive strength parallel to the grains

Index	Standard deviation indicators					Water content %	Density kg/m^3
	Aver., N/mm^2	St.Dev. N/mm^2	Ser N/mm^2	Var %	p %		
FN	46.71	1.69	0.42	3.62	0.9	8.6	786
FS	44.89	4.41	1.10	9.81	2.4	1.8	1082
PN	30.82	1.02	0.25	3.31	0.8	10.5	419
PS	30.15	2.15	0.54	7.15	1.8	1.6	1013
SN	27.86	0.91	0.23	3.25	0.8	10.8	421
SS	25.20	2.08	0.52	8.27	2,1	5.2	569

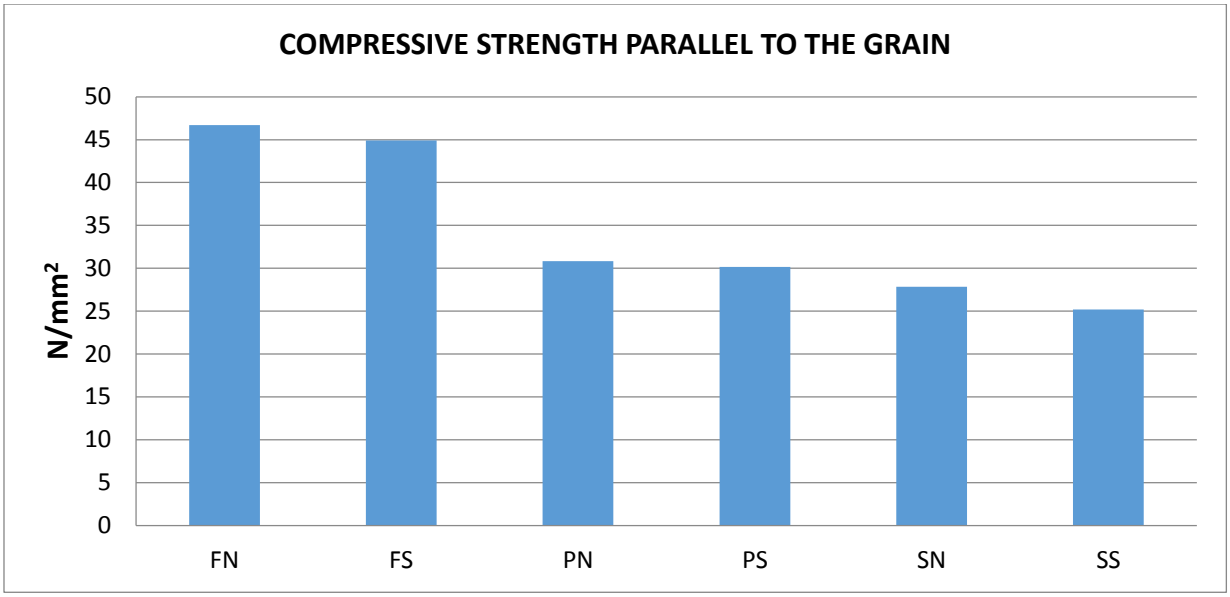


Fig.4.Diagram of compressive strength parallel to the grains

Tabl. 6. Static bending strength

Index	Standard deviation indicators					Water content, %	Density kg/m^3
	Aver. N/mm^2	St.Dev N/mm^2	Eror. N/mm^2	Var %	p %		
FNR	109.03	5.69	1.42	5.2	1.3	8.6	786
FNT	101.77	6.21	1.55	6.1	1.5	8.6	786
FSR	76.51	4.59	0.87	6.0	1.1	1.8	1082
FST	61.38	5.28	1.32	8.6	2.1	1.8	1082
PNR	62.36	6.31	1.58	10.1	2.5	10.5	419
PNT	58.60	7.26	1.82	12.4	3.1	10.5	419
PSR	44.14	6.59	1.64	14.9	3.7	1.6	1013
PST	43.82	6.68	1.67	15.2	3.8	1.6	1013
SNR	66.38	8.24	2.06	12.4	3.1	10.8	369
SNT	55.71	6.51	1.63	11.7	2.9	10.8	369
SSR	38.61	7.42	1.85	19.2	4.8	5.2	421
SST	34.43	5.36	1.34	15.5	3.9	5.2	421

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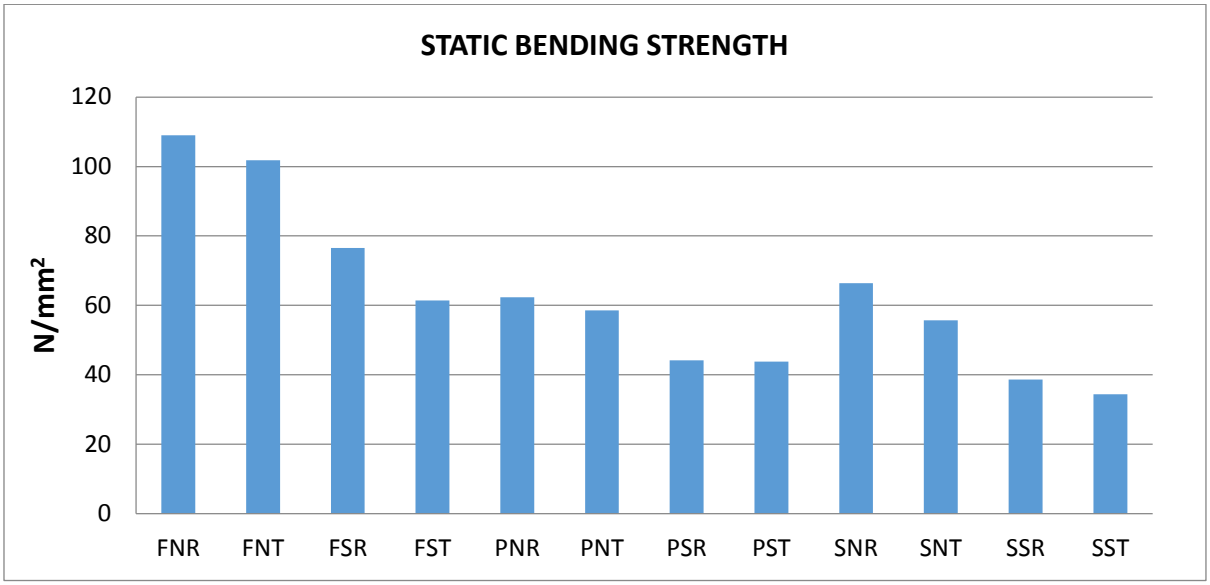


Fig.5. Diagram of static bending strength in radial and tangential direction

Test samples about shearing strength are present in fig.6. In tabl.7 and fig.7 are presented average value of the shearing strength parallel to the grain. The results shows that thermally treated wood have lower values about sharing strength. Sharing strength decreased in beech wood with 46.5% in radial and 41.8% in tangential direction after treatment. The changes in poplar wood are most notable; sharing strength reduces 57.1% in radial and 57.7% in tangential direction. Spruce wood sharing strength reduces lowest. The all results are reliable; because Student coefficient has values more of 3.

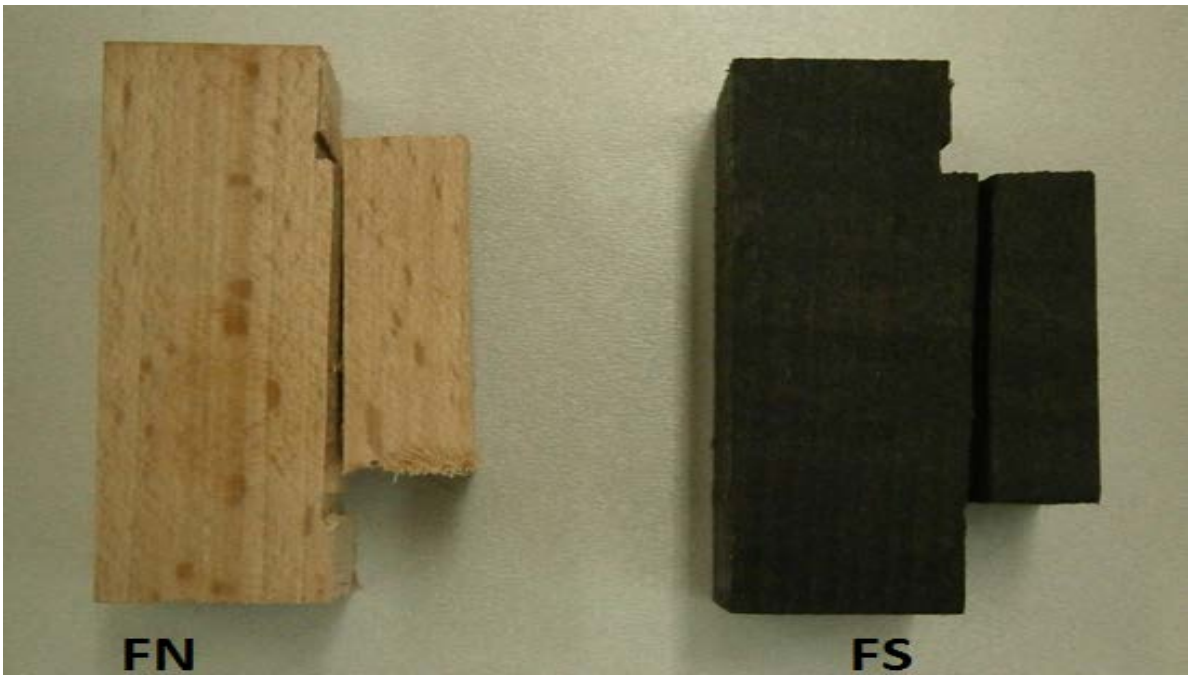


Fig.6. Sharing strength test samples: at left untreated beech; at right modified beech

Tabl.7. Shearing strength

Index	Standard deviation indicators					Water content, %	Density kg/m^3
	Aver. N/mm^2	St.Dev N/mm^2	Eror. N/mm^2	Var %	p %		
FNR	19.31	1.99	0.49	10.3	2.6	10.8	786
FNT	20.53	2.37	0.59	21.5	2.9	10.8	786
FSR	10.32	1.85	0.46	17.9	4.5	3.5	1082
FST	11.95	2.06	0.52	17.2	4.3	3.5	1082
PNR	9.21	1.45	0.36	15.7	3.9	11.5	419
PNT	11.48	1.86	0.46	16.2	4.0	11.5	419
PSR	3.95	0.85	0.21	21.5	5.3	2.3	1013
PST	4.86	0.78	0.19	16.1	4.3	2.3	1013
SNR	10.08	1.78	0.45	17.6	4.5	10.7	369
SNT	12.30	2.14	0.53	17.4	4.3	10.7	369
SSR	7.12	1.36	0.34	13.1	4.7	4.1	421
SST	8.31	1.45	0.36	17.4	4.3	4.1	421

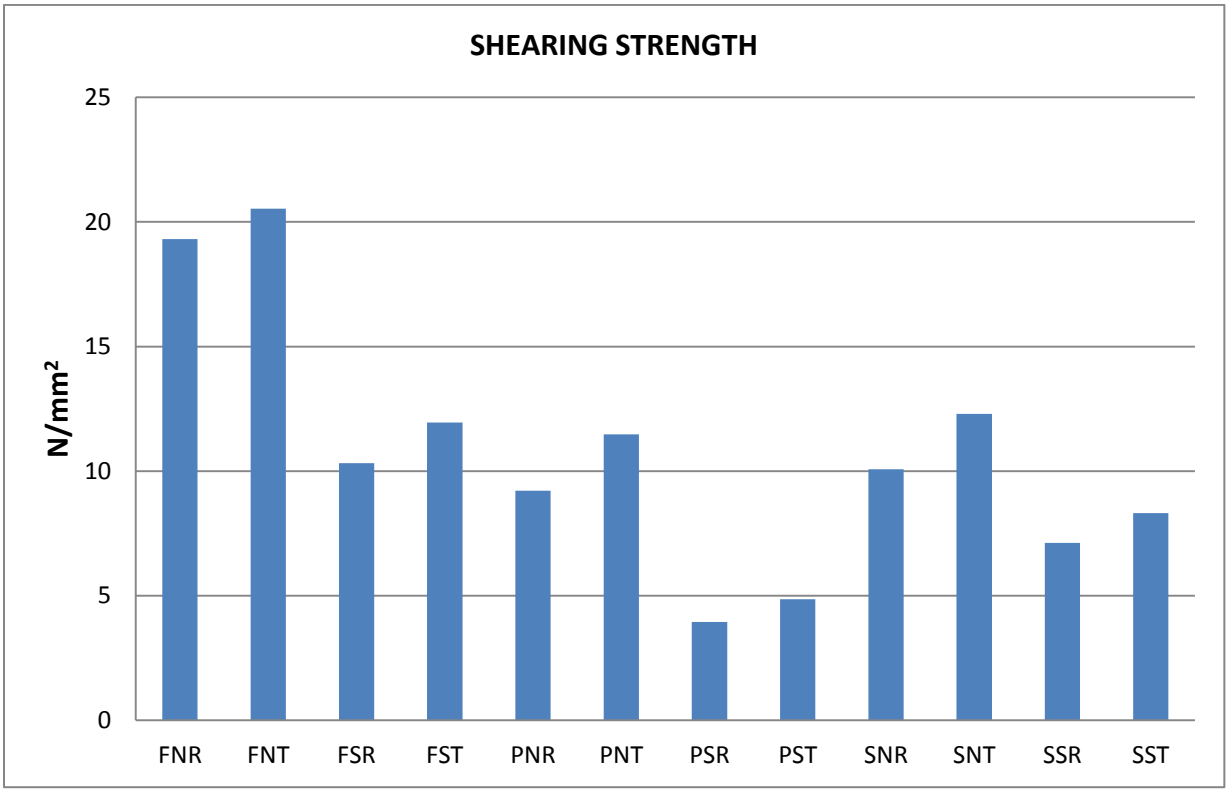


Fig.7. Diagram of shearing strength in radial and tangential direction.

The received results about splitting strength are present in tabl.8 and fig8. Test samples about splitting strength are present in fig.9. Analysis of the results is that splitting strength of thermally modified wood is lower than natural. This is valid for all wood spies. The differences are reliable with Student coefficients higher than 3.

Tabl.8. Splitting strength

Index	Standard deviation indicators					Water content, %	Density kg/m^3
	Aver. kN/m	Stand.Dev kN/m	Eror. kN/m	Var %	p %		
FNR	63.61	5.82	1.45	9.1	2.3	11.2	786
FNT	58.16	7.23	1.81	12.4	3.1	11.2	786
FSR	25.38	0. 65	0.16	2.6	0.6	3.21	1082
FST	14.88	1.63	0.41	10.9	2.7	3.21	1082
PNR	30.83	2.48	0.68	8.2	2.2	11.3	419
PNT	33.64	5.37	1.34	15.8	3.9	11.3	419
PSR	16.81	1.26	0.32	7.5	1.9	3.25	1013
PST	15.88	3.42	0.85	21.3	5.3	3.25	1013
SNR	20.44	4.21	1.05	20.6	5.2	10.6	369
SNT	27.31	6.75	1.68	24.7	6.1	10.6	369
SSR	15.14	2.85	0.71	18.8	4.6	3.15	421
SST	13.77	2.27	0.57	16.4	4.1	3.15	421

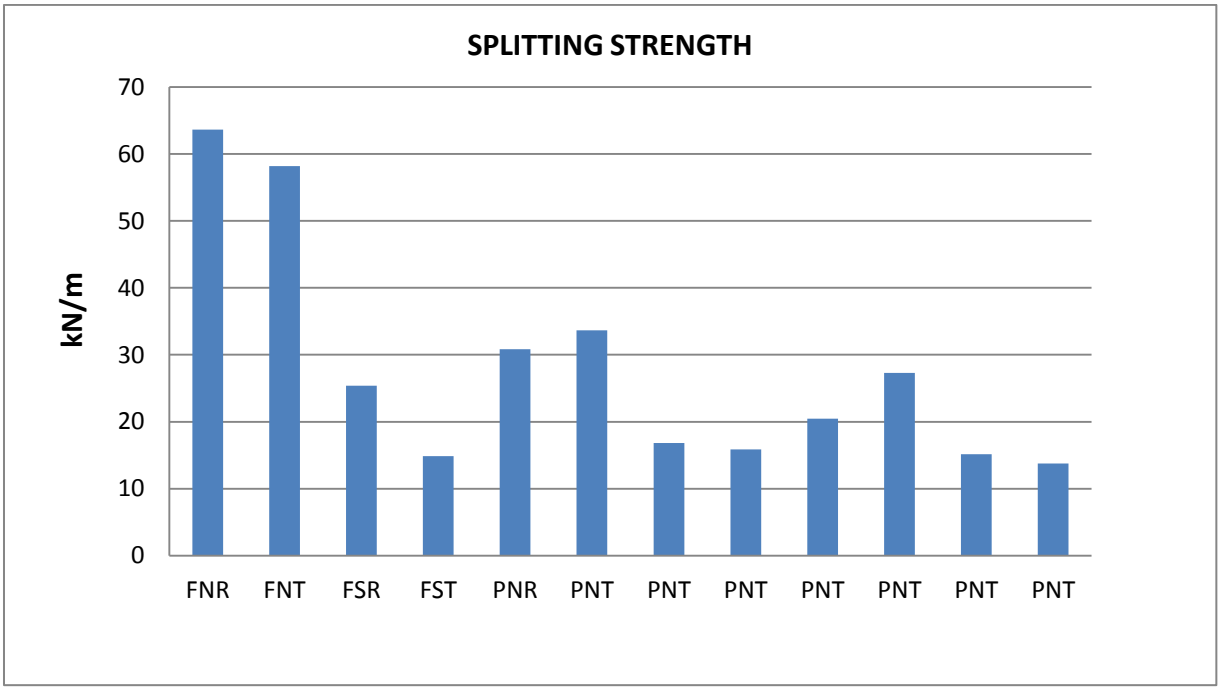


Fig. 8. Diagram of splitting strength in radial and tangential direction

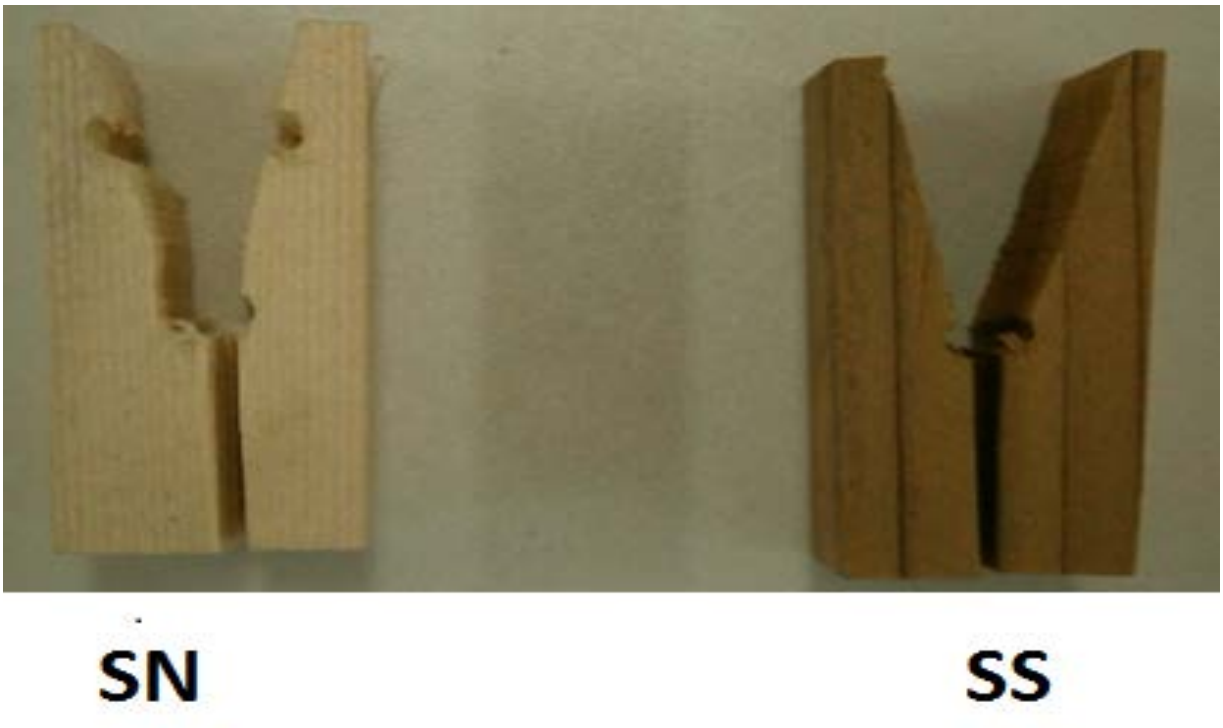


Fig.9. Splitting strength test sample: at left untreated spruce; at right modified spruce.

The received results about impact strength are present in tabl.9 and fig.10. Analysis of the results is that splitting strength of thermally modified wood is lower than natural. This is valid for all wood spies. The differences are reliable with Student coefficients higher than 3.

Tabl. 9. Impact strength

Index	Average J/cm^2	St.Dev. ± J/cm^2	Ser ± J/cm^2	V, %	p, %	Water content, %	Density kg/m^3
FN	19.179	0.879	0.219	4.6	1.14	10.3	786
FS	18.589	1.593	0.398	8.6	2.14	3.2	1082
PN	15.239	1.432	0.358	9.4	2.34	11.2	419
PS	13.185	1.237	0.309	9.3	2.34	3.4	1013
SN	18.688	1.842	0.461	9.8	2.46	10.9	421
SS	16.039	0.656	0.164	4.1	1.02	3.2	569

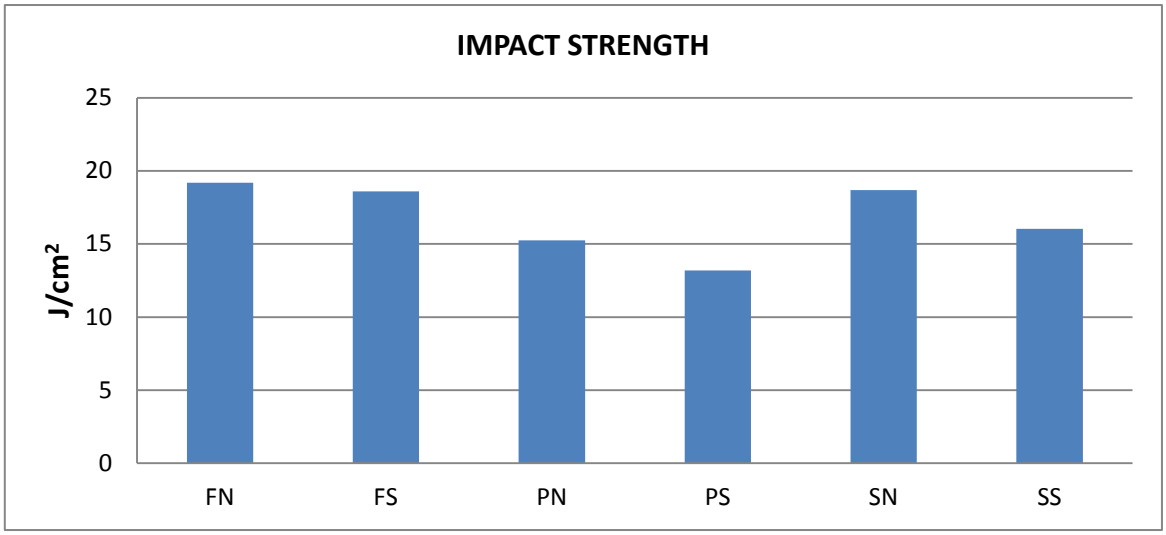


Fig.10. Diagram of impact strength



Fig.11. Cultural flask with spawns of Poria placenta (Fr.) 125 a EbW

Fungus resistance is defined towards Poria placenta (Fr.) 125 a EbW and Coniophora puteana (Fr.) Karst, which caused brown rot on maltagarmedium (4% malt and 2% agar) in cultural flasks (fig.11).

In fig.12 is present cultural flask with natural spruce sample, exposed on Poria placenta's spawns. About relation is used thermally modified wood, produced by Lunawood Ltd. – Finland, received in hot damp thermally condition. In fig.13 is present cultural flask with this sample exposed on Poria placenta's spawns. In Fig.14 are present cultural flask thermally treated in sunflower oil spruce samples (SS), exposed on spawns of Poria placenta.

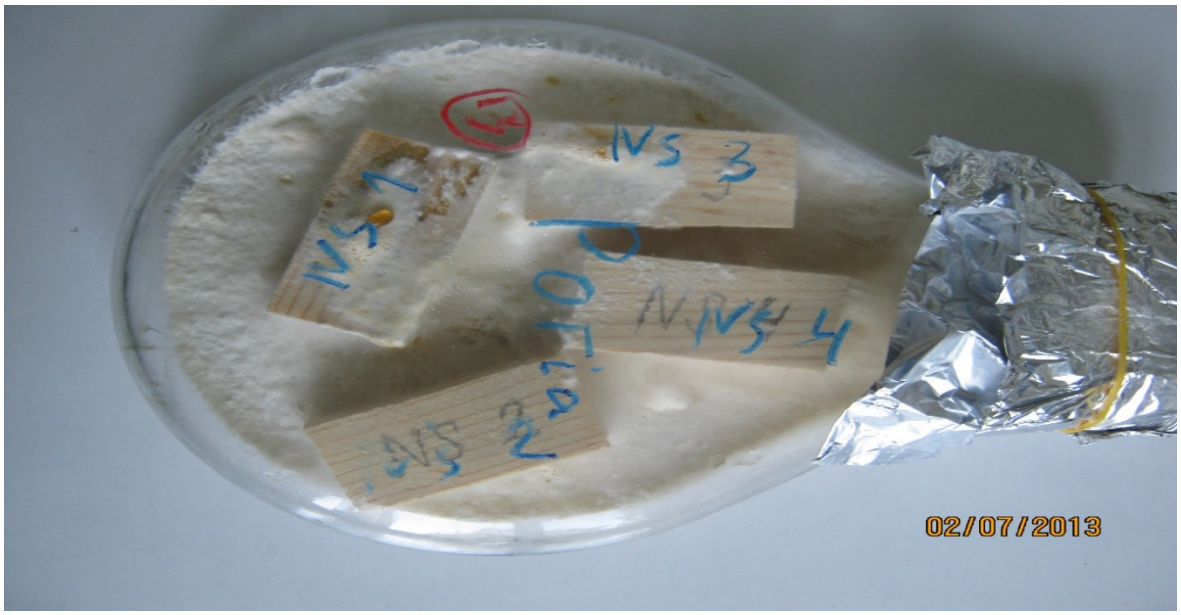


Fig.12. Cultural flask with natural spruce wood exposed on Poria placenta's spawns

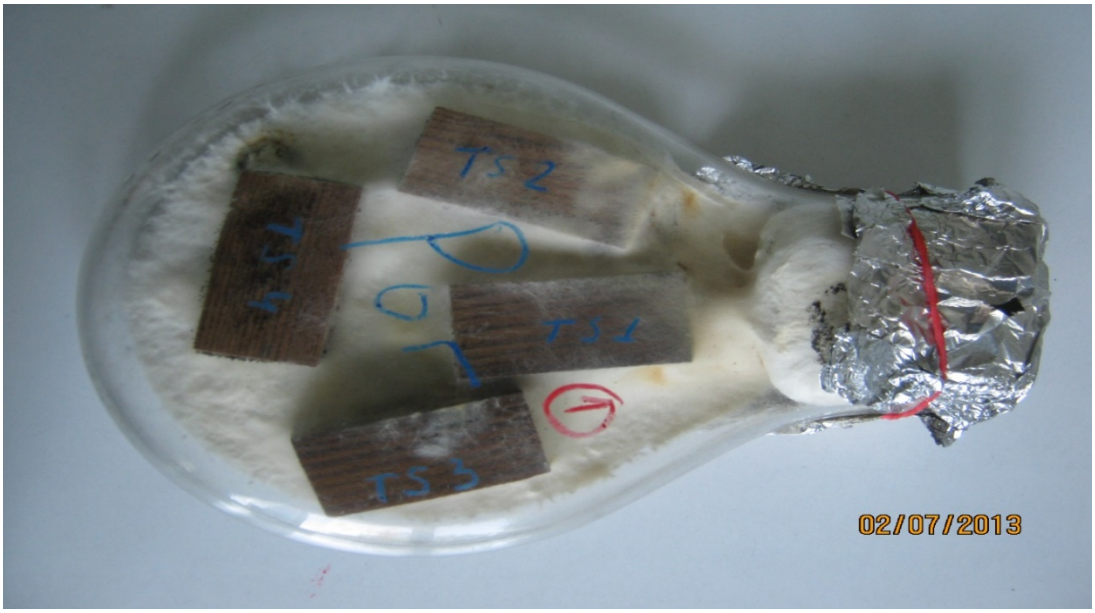


Fig.13. Cultural flask with thermally treated spruce wood produced by Lunawood (TS) exposed on Poria placenta's spawns



Fig.14. Cultural flask with heat treated in sunflower oil spruce wood exposed on Poria placenta's spawns

The received results, about sample's mass losses after exposure on spawn of selected fungus, are worked with standard deviation methods and presented in tabl.10 and fig.15. In tabl.10 are presented values of sample's density in absolutely dry condition, their gained wet content after 16 week exposure on fungus spawns of Poria placenta и Coniophora puteana. It has a good sight that, as a consequence of the development of wood decaying process timber accumulates water. The water values in modified wood is a higher than in natural.

Tabl. 10. Fungus resistance of spruce: natural and thermally modified wood

Index	Poria placenta (Fr.) 125 a EbW				Coniophora puteana (Fr.) Karst.			
	Density D_0 kg/m^3	W, %	Mass loss %	Average error %	Density D_0 kg/m^3	W, %	Mass loss %	Average error %
Natural (NS)	415	53.8	22.42	0.59	418	72.3	41.92	0.95
Thermally modified in air environment (TS)	448	68.1	2.67	0.27	442	83.6	6.55	1.65
Thermally modified in sun-flower oil (SS)	440	125.0	11.80	0.68	437	138.2	18.23	0.77

The average value about gained water in series with natural spruce wood after exposure on spawn of Poria placenta is 53.8 %. The modified spruce wood in air environment series is gained water after exposure on spawns of Poria placenta average 68.1 %. The modified spruce wood in sunflower oil is gained water after exposure on spawns of Poria placenta average 125.0 %. The same tendency is valid after exposure on spawns of Coniophora puteana (Fr.) Karst., but the values are higher. In the competitive analysis of mass losses values are concluded, that thermally modified wood in air environment have lowest one: 2.67 % of Poria placenta and 6.55 % of Coniophora puteana. The mass losses values of thermally modified in sunflower oil are vastly higher, respectively 11.80 % of Poria placenta and 18.23 % of Coniophora puteana, which are two times lower than natural spruce wood: 22.42 % of Poria placenta and 41.92 % of Coniophora puteana. The differences between values of mass losses are standard deviation proved. The mass losses difference after exposure on Poria placenta between natural (22.42 %) and finish thermally modified wood (2.67 %) is reliable, because the coefficient of Student has a value 30.4, which one is higher of 3. The mass losses difference after exposure on Poria placenta between natural (22.42 %) and thermally modified in oil wood (11.80 %) is reliable, because the coefficient of Student has a value 11.8, which one is higher of 3. The differences of mass losses of Poria placenta (9.13%) between modified in sunflower oil wood (11.80%) and finish thermally modified wood (2.67) is reliable, because the Student's coefficient have value 12.3, which is higher than 3.The mass losses difference after exposure on Coniophora puteana between natural (41.92 %) and finish thermally modified wood (6.55 %) is reliable, because the coefficient of Student has a value 18.6, which one is higher of 3. The mass losses difference after exposure on Coniophora puteana between natural (41.92 %) and thermally modified in oil wood (18.23 %) is reliable, because the coefficient of Student has a value 19.4, which one is higher of 3. The differences of mass losses of Poria placenta (11.68%) between modified in sunflower oil wood (18.23%) and finish thermally modified wood (6.55) is reliable, because the Student's coefficient have value 6.44, which is higher than 3. Therefore there is evidence to suggest, that wood thermally modification increase fungi resistance of Poria placenta (Fr.) 125 a EbW and Coniophora puteana.

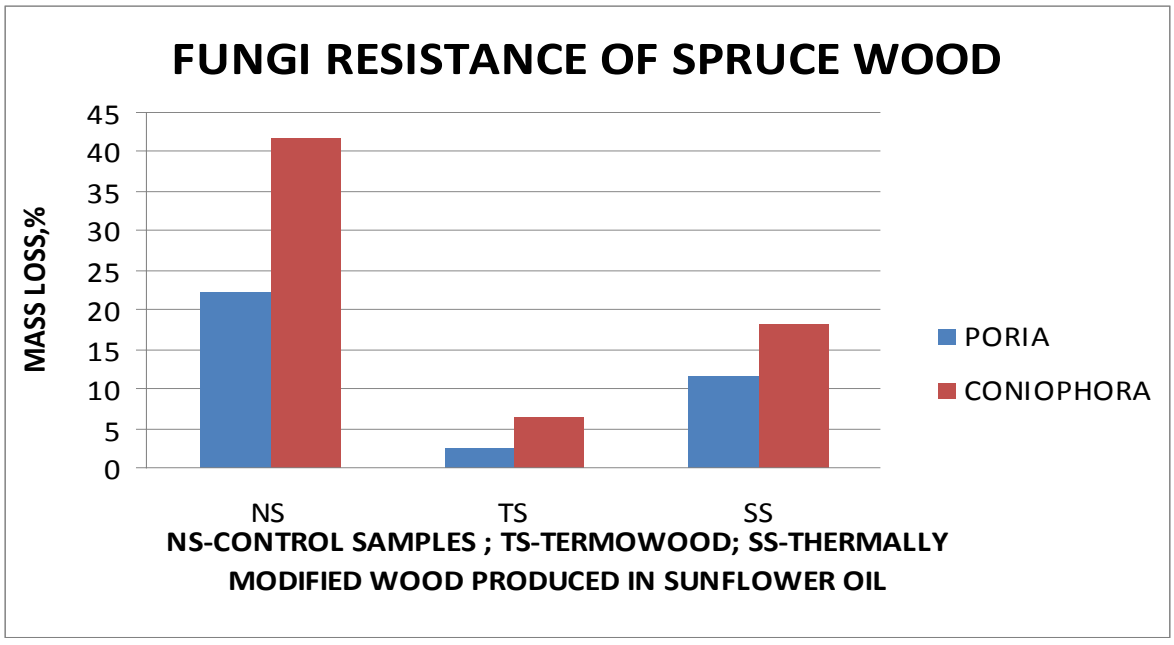


Fig.15. Fungus resistance of spruce natural and thermally modified wood

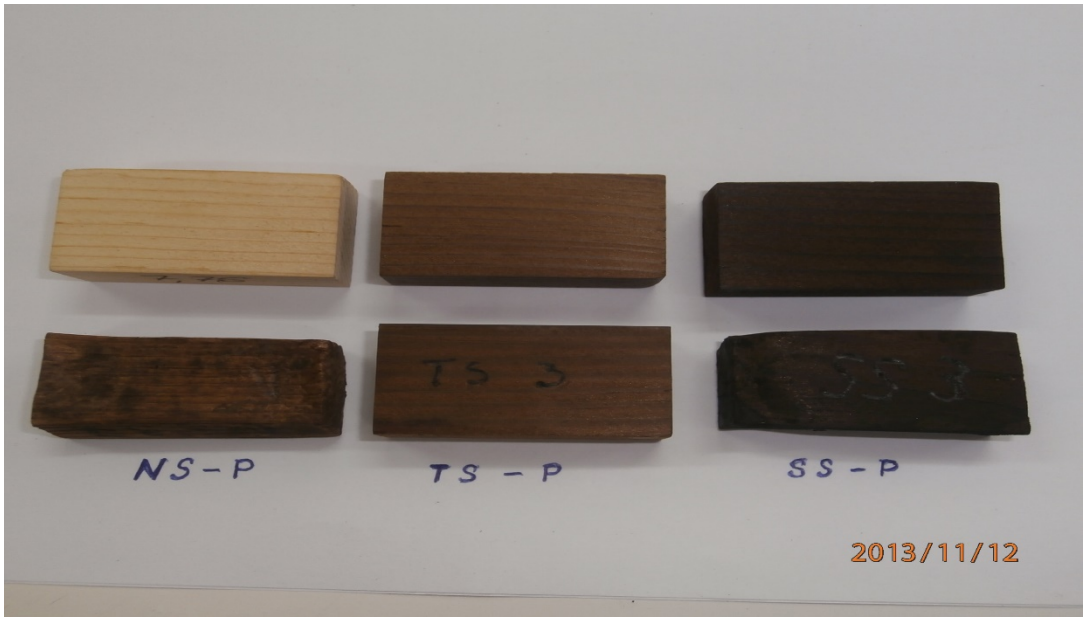


Fig.16. Spruce wood samples before and after exposure on spawns of Poria placenta: NS-P natural spruce wood samples; TS-P-thermally treated samples in air environment; SS-P- thermally treated samples in sunflower oil.

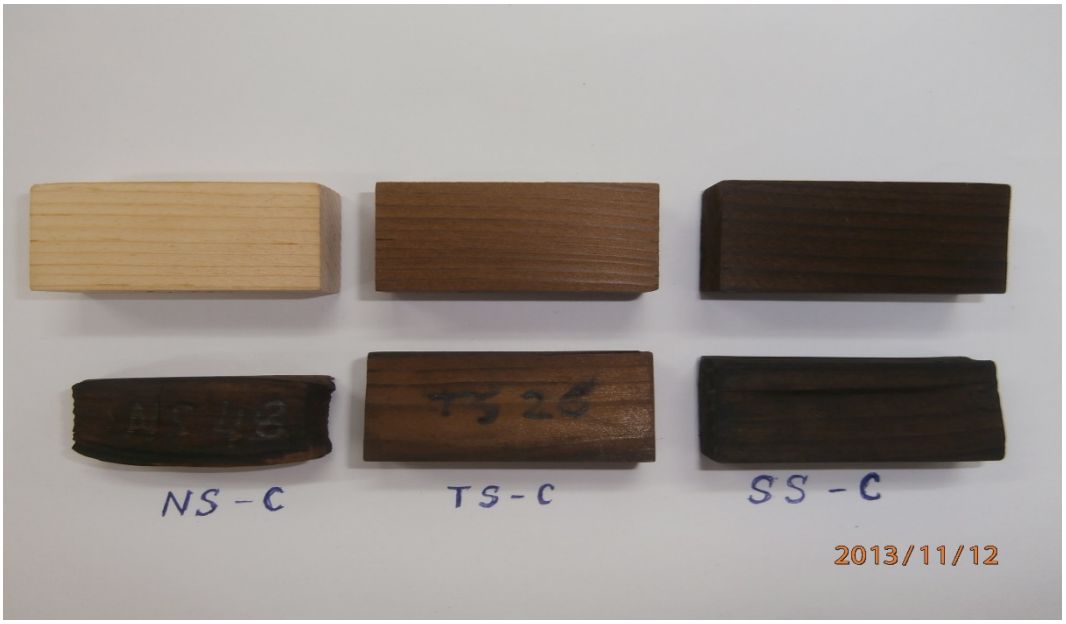


Fig.17. Spruce wood samples before and after exposure on spawns of Coniphora puteana: NS-C- natural spruce wood samples; TS-C-thermally treated samples in air environment; SS-C- thermally treated samples in sunflower oil

CONCLUSION AND RECOMMENDATION

After analysis of received results can made following conclusion:

1.Thermally modified wood in sunflower oil have reduced hygroscopicity and improved dimensional stability.

2.Thermally modification in sunflower oil reduced values of mechanical properties. It is valid for all searched wood types. This problem comes from remaining quantity of heat medium in wood and chemical changes in wood. Remaining quantity in wood have a more powerful.

3. Thermally modification in sunflower oil reduced wood destruction after exposure on spawns of Poria placenta и Coniophora puteana.

4. Fungus resistance of thermally modified wood in sunflower oil is not enough to be classified like material with high durability (BDS EN 350/1).

5. Wood destroying fungi: Poria placenta (22.42±0.59%) and Coniophora puteana (41.92±0.95%) are strong destructors about spruce wood.

6.Industrial produced thermally modified wood have a better resistance to Poria placenta (2.67±0.27 %) and Coniophora puteana (6.55±0.68 %).

7. Thermally modification in glycerol heat medium made wood more hygroscopicity than untreated wood.

All received results about thermally wood modification in sunflower oil are good basis for next searches to improved mechanical properties, fungus resistance and wood dimension stability.

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