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RESEARCH THE INFLUENCE OF THE WEATHERING FACTORS OVER DURABILITY OF TEAK TIMBER DEKING

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Abstract

It was made an investigation of weathering factors over durability of teak timber decking in both real and laboratory conditions. For the purpose of the research were used teak timber samples (some of them were treated with oils, waxes, varnishes on oil basic and others were not treated at all). It was studied the influence of the water-thermal and radial impact on the change of appearance, weight and size of samples, which is regulated by BDS EN ISO 2812/2:2007, BDS EN ISO 1507:2007, BDS EN ISO 2810:2004. The change of the appearance of the samples is being estimated by grade system that is regulated by BDS EN ISO/1:2003. Parallel with this was studied the change in the adhesion of coats due to the weathering. As a result of the made investigations was estimated that the durability of decking depends on the wood structure and the type of the varnishes. On the base of the made conclusions is recommended renovation of coats 2 times in the year, the most suitable varnishes are these that are on the base of tung, linseed and teak oil.

Key words: *teak timber; weathering factors; decking; durability of wood; wax coats;*

1. INTRODUCTION

Greater part of wood constructions are used outdoors. Due to the weather conditions they can get damaged , i.e. to be attacked by fungi and insects, to crack because of the change in humidity and temperature, to damage under the influence of UV rays or to get warped. Construction elements that are used in such structures can be classified in 2 groups: building elements and decking elements. Decking elements can be classified in few smaller groups: elements for indoor wall facing; elements for outdoor wall facing; elements for indoor floor facing (flooring, parquet, parquet boards); elements for outdoor floor facing (decks, pathways); elements for ceiling facing. Depending on the situation and the function of the construction can be chosen the most suitable timber. For deck facing elements of vessels (yachts, cutters, ships) or floor facing near swimming pools, is preferred tropical timber that is rich of resins mineral substances, for example teak, hickory, ipe, glabra, etc. On Fig.1 can be seen pictures of teak “decking” structures. “Deck” or “decking” structures represent floor planking, mostly made of solid timber of exotic wood species, that are used for facing of terraces, verandas, gardens, open grounds near swimming pools, in bathrooms, SPA centers, coastal alleys, outdoor bars and etc. “Decking”, also called garden flooring or exterior parquet, is made of different types of teak timber, ipe timber which can be find in Africa, Asia, North and South America. The basic indicators of outdoor wood facing are: durability, solidity, wear resistance, humidity resistance, heat, sound insulation, flat surface, color and etc. They are the real connection of exterior with Nature, [17; 19]. In architecture “Decking”, also called garden parquet, garden flooring or exterior.

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Fig.1: Pictures of objects with teak timber constructions and facing elements **(***Tectonia grandis L***)**

parquet, represents plane surface that is capable to stand a huge load. It is similar to the floor but is constructed outdoors, often is a little lifted over the ground and is connected with the building itself. “Deck” and “decking” are appellations that are taken from terms in yachting. “Decking” means deck of a sailing-boat or yacht. Very often “deck” is used as a synonym of veranda, terrace, patio and boards. As a term “decking” signify a process of special wood facing setting in yards, gardens, near swimming pools, sauna and is getting a popular part of exterior and landscape design, [17]. Solidity of wood means its ability to resist against physical, chemical and biological influence of the environment and also to keep its technological characteristics (color, texture, density, hardness, solidity and etc), [15]. The influence of weathering factors over the durability of timber is determined by the character and the degree of wood demolition during its exploitation or the so called weathering. As a process erosion represents comparatively slow injury of wood surface during which for a term of 100 years a

wood layer of 2 to 10 mm is being injured: for hardwoods the layer is 2 to 5 mm and for softwoods – 5 to 10 mm, [15]. The basic factors that have influence over polymers' erosion and destruction can be separated in 2 groups: 1) Internal - polymers' composition and structure, molecular mass, internal tension, defects and etc. 2) External – temperature and relative humidity of air, water and sun radiation. This is valid for timber too. To external factors can also be added oxygen, aggressive gases, mechanical loading of wind. The biological influences give evidence in certain conditions and should be taken into consideration. Despite the elementary chemical composition of the cell wall is approximately equal for all of the species, their durability differs from one another. The reason for this is due to the different extract and substance content. As a rule these substances (resins, butyric acids, turpentine, tanning extracts, phenols, ethereal oils, coloring substances and etc) increase the durability of wood. It is considered that the higher the density is, the higher the durability is. Other internal factors that are of great concern are: time of felling, exploitation conditions and preservation. Nevertheless the UV rays penetrate into timber in 75 – 100 μm depth, they ate the main cause for wood destruction and provoke physical and chemical processes. As a result of the combined influence of the rest weathering factors can be achieved a great amount of serious structural changes in wood surface. This have an impact on esthetic appearance of the articles and the quality of varnishes, [14]. As a general, the process of surface erosion can be defined in this way: as a result of the activating influence of UV radiation, in wood macromolecules starts chemical transformation of lignin. After its fractional destruction, water washes out the destructed substance and reduces the connections between cellulose fibers. On the other side, this factor provokes repeatedly swelling and drying up of wood, consequently on its surface appear cracks that open up a chance for additional UV radiation. Except UV radiation from the sun, water also plays a part in the process of wood destruction. Their interaction with wood is of great concern for timber weathering. Water contributes for the formation and development of free radicals, which are the reason for wood destruction. Despite timber does not contain free radicals, when the weathering factors interact with different kinds of physical and mechanical loadings, a great amount of free radicals are produced. Another important element that has influence over the processes of wood weathering is the oxygen from the environment. In the process of photo- oxidation , the oxygen is added to some other free radicals and forms peroxide radicals. Other basic factors are the aggressive gases from the atmosphere. The sulphur dioxid content in the environment accelerates wood erosion because it is easy soluble in water. In winter the determinant meaning of aggressive gases is specified from the intensive heating and from the fog accumulation and this leads to critical concentration of gases. Therefore for long-term timber usage it is recommended the outdoor wood constructions to be varnished in advance. The influence of the weathering factors compulsory should be taken into consideration – UV radiation, water, oxygen from air and etc. The problem with weather-proof assessment of timber is of great concern when choosing the appropriate timber kind and protective means. There are two methods of such assessment. The first one consist in the following: the samples are exhibited outdoors in real climate conditions. In this kind of exhibition is used a stand made of noncorrosive materials which ensure the secure fastening of samples over it and the free change of sample sizes. The disadvantage of this method is the long duration of the exhibition process. On the other hand, the conditions during the exhibition of samples are the same with these in real usage of articles. The second way of timber weathering consist of using a device for accelerated examination and the time can be extremely reduced. The advantage here is possibility for controlling of experiment parameters in desired limits. The conditions of the accelerated weathering are connected with the specific climate conditions in real usage of articles. Their formulation depend on the type of the material, the function of the article and the protective means. As a result of the made problem survey and the derived conclusions, was laid the following purpose: investigation of weathering factors over durability of teak timber decking.

2. MATERIALS AND METHODS

The samples that are needed for the experiment are made of teak timber (*Tectonia grandis L.*). The samples for the accelerated weathering are 6 pieces with size 20/100/300 mm. The samples for the real weathering are 6 pieces with size 20/100/300 mm. The samples for determining the adhesion are 6 pieces with size 20/50/300 mm. For the purpose or the investigation are chosen the following oils, waxes and varnishes, they are shown in Table 1. These products can be found on Bulgarian market: Teak oil; Valtti Oil; Valtti Exterior Wax; Osmo Teak Oil. For comparison are chosen also Yacht varnish (uretan-alcid) which is used in shipbuilding and the unknown to the Bulgarian customers Tung oil. These products are based on natural plants and oils (sunflower-seed oil, soy-bean, linseed, teak and tung oil) and waxes (beeswax). The non-volatile ingredients content (dry content) is determined by BDS EN ISO 3251:2006, equation (1):

$$M_c = \frac{M_3 - M_1}{M_2 - M_1}.100,\% \qquad (1)$$

M_1 ***- weight of evaporated ingredient, g***

M_2 ***- weight of the cup with the liquid sample, g***

M_3 ***- weight of the cup with the dry sample, g***

Table 1: Characteristics of used protective products

Index	Name of the product	Producer	Characteristics			
			M_c %	D kg/L	η s	pH
TgO	Tung Oil Lacquer	Kremer pigmente- Germany	60	898	17	5
TkO	Teak Oil	Vivechrom- Greece	34	852	50	6
VaO	***Valtti Oil Akvacolor***	Tikkurila- Finland	36	993	12	8
YV	Yacht Varnish	Levis- Belgium	57	908	280	6
VEW	Valtti Exterior Wax	Tikkurila- Finland	42	1020	30	8
OTkO	Osmo Teak Oil	Osmo Holz and Colour- Germany	58	875	15	5

Viscosity of used protective means is defined by DIN-4 and pH is defined by indicator paper. Tung Oil Lacquer is a product of the German company Kremer pigment. It is compound of tung and linseed oil, sicativated with a mixture of sicatives which provides quick passing into solid state (quick dry). The surface is touch-dry in 2h and recoatable after 24h. The hard film is elastic and does not become yellow. It has nice amber color. The lacquer can be colored with appropriate dyes and pigments. Teak oil is a product of the Greek company Vivechrom. It is a mixture of natural oils and waxes, the teak oil here is predominant. The surface is touch-dry in 3h and recoatable after 48h. The product Valtti Oil Akvacolor is waterborne semi- transparent mat wood finish. It is a product of the Finnish company Tikkurila. The surface is touch-dry in 3h and recoatable after 24h. The Yacht Varnish is an organic soluble colorless product of the Belgian company Levis. It forms glossy water resistant surface that is

touch-dry in 4h and recoatable after 24h. The water-repellent product Valtti Exterior Wax is produced by the Finnish company Tikkurila. It is compound of oils, sicatives, waxes and pigments which are emulsified in water. It forms mat copper – brown surface that is touch-dry in 2h and recoatable after 24h. Osmo Teak Oil (clear oil wood finish) is a product of the German company Osmo Holz and Color. It is a compound of natural plant oils (linseed, sunflower seed, soy-bean seed), sicatives and waxes. It also contains 2-butanoxim, which give wood surface resistance to moulds, fungi and insects. The product can be colored with dyes and pigments. The surface is touch-dry in 12h and recoatable after 72h. The hardness of the dry coat, that is formed over a glass tile with size 4/50/90 mm, is defined by pendulum device M-3, that is regulated by BDS ISO 1522:2007. The hardness of the dry surface that is formed over the teak samples is defined by the Shore A device, model HT-6510A, it is regulated by ISO 7619 (Fig.2). The adhesion of the laid finishes to the wood surfaces is defined by the "Pull off adhesion method", it is regulated by BDS ISO 4624:04.

Adhesion is estimated by equation (2):

$$\sigma_a = 0.032.F, N/mm^2 \quad (2)$$

F – force of destruction, kg

The thickness of the solid finish is regulated by BDS ISO 2808:2002. It is defined by micrometer with 0.01 mm precision (10 μm), (Fig.3).

The natural weathering of polymer vanishes is regulated by BDS ISO 2810:2004, [11]. The climate influence over the processes of timber weathering is due to the variations in temperature, humidity, amount of precipitations – rain, snow, amount of sunny and foggy days, speed and wind direction, air pollution, amount of sun radiation and angle of ray incidence. The duration of timber weathering depends on a couple of factors – way and intensity of exploitation.

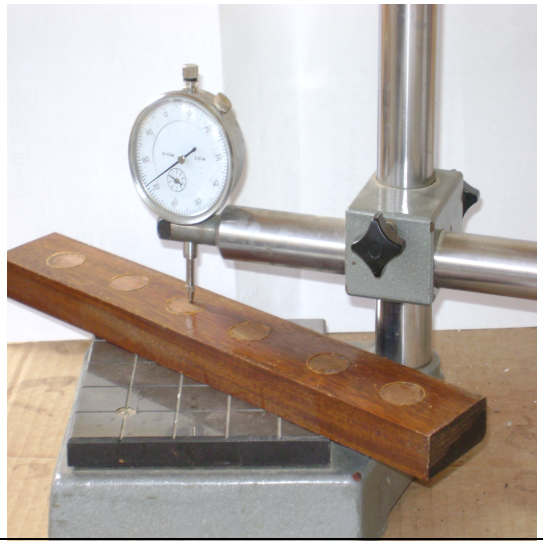


Fig.2. Shore A device

Fig.3. Micrometer

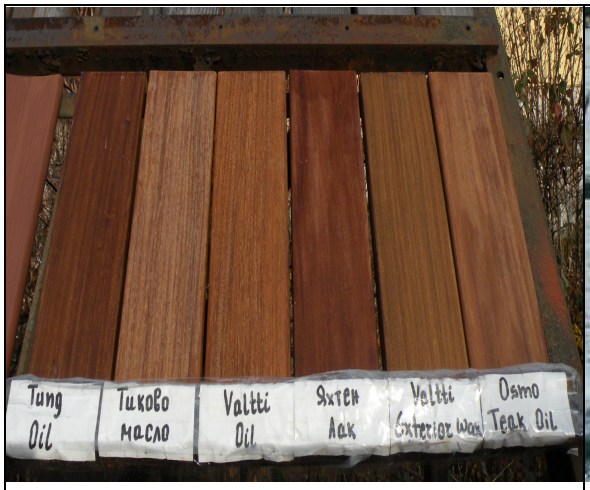


Fig.4.Teak timber samples, places outdoors: 10.2009



Fig.5.Teak timber samples, places outdoors: 12.2009

Six samples with size 20/100/300 mm and placed over a stand in the yard of University of Forestry – Sofia. The stand is with south – southeast exposure. The samples are placed at angle of 45º towards the horizon and at 1,5 m height. The stand is placed over plane concrete area is made of stainless steel and colored with anticorrosive black paint. The stand is with frame construction, which allows free air circulation. The minimum term of sample weathering is 1 year. It is important to note that the experiment should start at the same time every year, the most appropriate season is spring. Samples should be measured at regular intervals (weight and 3 thicknesses – in the middle and in both ends) and when defects appear they should be rated (stains, unstuck, cracks in surface and timber). Six samples with size 20/100/300 mm are subjected to accelerated weathering in laboratory conditions where real weathering factors are imitated (soaking in water, freezing, heating with IR light, irradiation with UV lamp). The regime of cyclic treatment is shown in Table 2. Other six samples with size 20/100/300 mm were varnished and stored in cupboard, they will be used as a standard.

Table 2: Regime of cyclic treatment

№	Type of influence over samples	Time, h	Repetition
1.	Soaking in desillated water at t = 20° C	24	3 cycles
2.	Freezing in refrigerator chamber at t = - 2° C	48	3 cycles
3.	IR heating	12	3 cycles
4.	UV irradiance	12	3 cycles

Through soaking of samples in water can be checked the water resistance of varnishes and also the stability of the polymer coat against water impact. This investigation is regulated by BDS ISO 2812/2:2007. For the purpose of the experiment is used tank with size 700/400/400 mm. The samples are placed in the tank at 30 mm distance from each other and from the tank walls. The samples should be pressed so they can not come to the surface. After 24h stay in the tank, samples should be taken out, dried with paper and after 1 minute should be taken their weight and measured their sizes with caliper – gauge (width and 3 thicknesses), it is regulated by BDS ISO 2802. Except this, the outward

appearance of samples should be estimated: change in color of varnishes, crack appearance. After that samples should be placed in refrigerator chamber for a period of 48h at t = - 2° C. In this way is imitated the real freezing of timber. After 48h samples should be taken out of the chamber and should be taken their weight and measured their sizes with caliper – gauge (width and 3 thicknesses), it is regulated by BDS ISO 2802. Samples appearance is being estimated once again. The next step of the accelerated sample weathering is stay in IR chamber for 12h. The chamber is supplied with 2 electric heaters, which are placed at 150 mm distance away from the samples, the temperature is t = (30 ÷ 80)°C. For this short time can be studied the influence of IR light over changes in timber structure and the condition of coats that are laid over it. The process of heating freeze timber are with practical significance. As a consequence of the low temperatures free moisture and part of the connected moisture can be find in solid condition, i.e. ice. The heating of freeze timber can be described with change in the physical condition of moisture – from solid into liquid and from liquid into gas, [13]. The process of heating freeze timber consist of 3 phases: 1) Wood temperature in the central and surface zones is quickly increasing to 0ºC. The surface layers heat quicker than the central layers. 2) Temperature of the surface layers is increasing quickly to the temperature of the environment. The temperature of the central zones keep permanent (0ºC), until ice melt and turn into liquid. 3) Temperature of the central and surface layers strives to reach the temperature of the environment, [13]. After 12h stay of the samples in the IR chamber should be taken their weight and sizes. The change of samples' thickness and width is regulated by BDS ISO 2802. Samples appearance is being estimated once again. The last step of the accelerated weathering of timber is stay of the samples in UV chamber for 12h. It is regulated by BDS ISO 1507:07, [9]. The irradiation with UV lamps in laboratory conditions imitates the real timber weathering but for a smaller period of time. For the purpose of the experiment is used chamber with UV lamp which has the following characteristics: 1) Waveband - λ = (340 ÷ 380) nm; 2) Temperature - t = 50 ± 3°C; 3) Specific power – (6 ÷ 8) kW. The UV lamps are quartz glass tubes, with inbuilt electrodes and filled with inert gas and fixed quantity of mercury. The power of the mercury UV lamps depend on the pressure of mercury fumes, i.e. from the quantity of mercury. In common lamps (with low and high power) about 8% of their power is being used for emission of UV rays and the rest is being generated in heat (the temperature can reach 700ºC), this can lead to overheating of varnished surfaces and defects, [16]. Samples are taken out of the chamber, their weight and sizes should be defined. Specific indicator of qualitative analysis of samples' surfaces is the "outward appearance" indicator. Through it can be received visual notion of coat condition. Assessment of coat demolition, assessment of the quantity, intensity and size of the defects that occur is regulated by BDS ISO 4628-1:2003, [10]. This standard concerns defects due to the timber weathering, influence of weathering factors over timber and also change in color due to the time. An unified agreement is being accepted for the purpose of correct assessment of defect size and quantity and also the intensity of their change through the time. There is a numeral grade scale from "0 to 5", where " 0 " shows no defects on the surface and " 5 " shows extremely huge amount of defects. When defining the quantity of defects all kinds of flaws should be taken into consideration. Defects are assessed according to their quantity, size and intensity as it is shown in Table 3, 4 and 5.

Table 3: Defect quantity degree

Grade	Degree of defect manifesting
0	No defects
1	Only a few defects
2	Small amount of defects
3	Average amount of defects
4	Significant amount of defects
5	Huge amount of defects

Table 4: Defect size degree

Grade	Degree of defect manifesting
0	Invisible with 10 times enlargement
1	Visible only with 10 times enlargement
2	Hardly visible with naked eye
3	Clearly visible with naked eye – up to 0,5 mm
4	Clearly visible with naked eye – from 0,5 to 5 mm
5	Defects with size over 5 mm

Table 5: Defect size degree

Grade	Degree of defect manifesting
0	No changes
1	Hardly visible change
2	Easily recognized defects
3	Well-defined defects
4	A large amount of defects
5	A huge amount of defects

3. RESULTS AND DISCUSSION

In Table 6 are shown the results of teak timber samples weight change after water absorption which are with size 20/100/300 mm. It can be clearly seen that water absorption is different for the different series. For example VEW - Valtti Exterior Wax after stage #1 the sample has absorbed 2,91% water, after stage #2 – 6,61 % and after stage #3 – 6,10 %. OTkO - Osmo Teak Oil after stage #1 the sample has absorbed 3,58 % water, after stage #2 – 6,71 % and after stage #3 – 6,13 %. TgO – Tung Oil - after stage #1 the sample has absorbed 0,86 % water, after stage #2 – 1,91 % and after stage #3 – 1,75 %. After this water absorption samples have swollen in thickness, the results are shown in Table 7. There can be seen that samples' swelling is proportional to water absorption results. The greatest values of thickness swelling can be recognized in OTkO series – after stage #1 is 3,96 – 2,91 – 3,47 %; after stage #2 is 1,52 – 1,19 - 1,46 % and after stage #3 is 2,68 – 2,03 – 3,57 %. The smallest values of thickness swelling can be seen in series treated with Teak and Tung oil. Teak oil - after stage #1 is 0,73 – 0,42 – 0,94 %; after stage #2 is 1,12 – 0,52 – 0,57 % and after stage #3 is 2,15 – 0,52 – 1,25 %. Tung oil - after stage #1 is 2,42 – 0,52 – 0,83 %; after stage #2 is 1,15 – 0,36 – 0,57 % and after stage #3 is 2,09 – 0,74 – 2,24 %. When talking about drying, the situation is similar (Table 8 and 9). The greatest shrinkage of samples is those of samples treated with Osmo Teak oil: 3,91 – 2,55 – 3,42 %, (Table 9). A similar tendency can be seen with the samples with smaller size – 20/50/300mm.

Table 6: Teak timber sample weight change with size 20x100x300mm after water absorption

Index	Stage I			Stage II			Stage III		
	M_o, g	M_f, g	$M_w, \%$	M_o, g	M_f, g	$M_w, \%$	M_o, g	M_f, g	$M_w, \%$
TgO	580	585	0.86	577	588	1.91	571	581	1.75
TkO	553	561	1.45	553	567	2.53	550	564	2.55
VaO	636	650	2.20	633	657	3.79	628	651	3.66
YV	524	536	2.29	524	542	3.44	518	536	3.47
VEW	515	530	2.91	514	548	6.61	508	539	6.10
OTkO	475	492	3.58	477	509	6.71	473	502	6.13

Symbol: *TgO –Tung oil; TkO –Teak oil; VaO - Valtti Oil; YV –Yacht Varnish; VEW - Valtti Exterior Wax; OTkO - Osmo Teak Oil;*

Table 7: Swelling of teak timber samples with size 20x100x300mm after water absorption

Index		Stage I			Stage II			Stage III		
		δ_o *mm*	δ_f *mm*	H_δ *%*	δ_o *mm*	δ_f *mm*	H_δ *%*	δ_o *mm*	δ_f *mm*	H_δ *%*
TgO	δ_1	19.04	19.50	2.42	19.14	19.36	1.15	19.08	19.48	2.09
	δ_2	19.12	19.22	0.52	19.20	19.34	0.36	19.04	19.18	0.74
	δ_3	19.22	19.38	0.83	19.27	19.31	0.57	19.23	19.66	2.24
TkO	δ_1	19.12	19.26	0.73	19.15	19.38	1.12	19.10	19.51	2.15
	δ_2	19.10	19.18	0.42	19.16	19.26	0.52	19.19	19.35	0.52
	δ_3	19.08	19.26	0.94	19.19	19.30	0.57	19.25	19.43	1.25
VaO	δ_1	19.10	19.42	1.68	19.16	19.57	2.14	19.16	19.64	2.51
	δ_2	19.12	19.30	0.94	19.16	19.45	1.89	19.20	19.33	0.68
	δ_3	19.50	19.95	2.31	19.09	19.55	2.04	19.45	19.71	2.67
YV	δ_1	19.30	19.84	2.79	19.11	19.37	1.36	19.13	19.42	1.52
	δ_2	19.16	19.32	0.84	19.20	19.28	0.42	19.09	19.24	0.79
	δ_3	19.16	19.44	1.46	19.15	19.65	2.61	19.16	19.60	2.29
VEW	δ_1	19.10	19.64	2.88	19.05	19.53	2.52	19.06	19.64	3.04
	δ_2	19.02	19.20	0.95	19.10	19.40	1.57	19.15	19.44	1.51
	δ_3	19.02	19.28	1.37	19.16	19.62	2.40	18.94	19.65	3.75
OTkO	δ_1	19.70	20.48	3.96	19.14	19.43	1.52	19.00	19.51	2.68
	δ_2	19.62	20.48	2.91	19.18	19.41	1.19	19.21	19.60	2.03
	δ_3	19.90	20.30	3.47	19.16	19.44	1.46	19.07	19.75	3.57

Symbol: δ_1 -thickness in the end; δ_2 -thickness in the middle δ_3 - thickness in the end; δ_o - initial thickness ; δ_f -final thickness ;

The received results give basis to maintain that the product with the best quality manifest is Tung oil (Mw = 1.75 %) and with the worst -Valtti Exterior Wax (Mw = 6.10 %) and Osmo Teak Oil (Mw = 6.13 %).

Table 8: Intermediate shrinkage of teak timber samples with size 20x100x300mm after cyclic treatment with IR and UV light

Index		Y,% - Stage I	Y,% - Stage II	Y,% - Stage III
TgO	δ_1	1.85	1.45	2.98
	δ_2	0.104	1.55	0.68
	δ_3	0.568	0.414	2.84
TkO	δ_1	0.57	1.44	2.61
	δ_2	0.104	0.363	1.55
	δ_3	0.363	0.26	2.47
VaO	δ_1	1.34	2.10	3.26
	δ_2	0.73	1.29	1.29
	δ_3	4.31	0.51	3.35
YV	δ_1	3.68	1.40	1.54
	δ_2	0.62	0.99	1.04
	δ_3	1.49	2.49	2.91
VEW	δ_1	3.00	2.41	4.02
	δ_2	0.52	1.29	2.37
	δ_3	0.62	3.47	3.82
OTkO	δ_1	6.54	2.21	2.97
	δ_2	6.35	1.03	2.45
	δ_3	5.62	1.90	2.68

In Table 10 and on Fig.6 is represented the information about change in weight of teak timber samples, treated with tung oil. After their soaking in tank with distillated water, where they should stay 24h and as a result of water absorption their weight increase , (M_w = 0.86 %) . The second step is stay of the samples in refrigerator chamber for 48h, the weight of samples decrease - (Y = 1.03 %). Third and fourth steps are irradiation of samples with IR and UV light, after that their weight decrease even more. There are 3 stages of timber treatment. At the end of second stage can be seen small amount of defects – coat rub off and cracks, due to water evaporation pressure and fundamental shrinkage (Table 9: 0.735 %- 0.366 %- 0.624 %).

In Table 11 and on Fig. 7 is represented the information about change in weight of teak timber samples, treated with teak oil. After their soaking in tank with distillated water, where they should stay 24 h and as a result of water absorption their weight increase (Mw = 1.45 %). The second step is stay of the samples in refrigerator chamber for 48h, the weight of samples decrease (Y = 1.08 %). Third and fourth steps are irradiation of samples with IR and UV light, after that their weight decrease even more (Y = 0.36 %). There are 3 stages of timber treatment. At the beginning of second stage can be seen

small amount of defects – coat rub off, due to water evaporation pressure and fundamental shrinkage (Y = 0.628 – 0.262- 0.681 %).

In Table 12 and on Fig. 8 is represented the information about change in weight of teak timber samples, treated with Vallti Oil. After their soaking in tank with distillated water, where they should stay 24h and as a result of water absorption their weight increase (M_w = 2.20 %). The second step is stay of the samples in refrigerator chamber for 48h, the weight of samples decrease (M_w = 1.88 %). Third and fourth steps are irradiation of samples with IR and UV light, after that their weight decrease even more (M_w = 0.47 %; M_w = 0.79 %). There are 3 stages of timber treatment. In the middle of second stage can be seen small amount of defects – coat rub off and cracks, due to water evaporation pressure and fundamental shrinkage(Y = 0.524 – 0.209- 2,308 %).

Table 9: Final shrinkage of teak timber samples with size 20x100x300mm, after cyclic treatment with IR and UV light

Index		Thickness dimensions		Shrinkage
		δ_o mm	δ_f mm	Y %
TgO	δ_1	19.04	18.90	0.735
	δ_2	19.12	19.05	0.366
	δ_3	19.22	19.10	0.624
TkO	δ_1	19.12	19.00	0.628
	δ_2	19.10	19.05	0.262
	δ_3	19.08	18.95	0.681
VaO	δ_1	19.10	19.00	0.524
	δ_2	19.12	19.08	0.209
	δ_3	19.50	19.05	2.308
YV	δ_1	19.30	19.12	0.933
	δ_2	19.16	19.04	0.626
	δ_3	19.16	19.03	0.678
VEW	δ_1	19.10	18.85	1.309
	δ_2	19.02	18.98	0.210
	δ_3	19.02	18.90	0.631
OTkO	δ_1	19.70	19.93	3.908
	δ_2	19.62	19.12	2.548
	δ_3	19.90	19.22	3.417

Symbol: TgO –Tung oil; TkO –Teak oil; VaO - Valtti Oil;
YV –Yacht Varnish; VEW - Valtti Exterior Wax; OTkO - Osmo Teak Oil;

Table 10: Weight change of coated with Tung oil, teak timber samples with size 20x100x300mm, after cyclic treatment

№ of stage	Initial weight	Water soaking – 24h		Refrigerator chamber – 48h		IR radiation – 12h		UV radiation– 12h	
	m g	m g	M_w %	M g	M_w %	m g	M_w %	m g	M_w %
I stage	580	585	0.86	579	1.03	578	0.17	577	0.35
II stage	577	588	1.91	583	0.86	574	1.54	571	2.10
III stage	571	581	1.75	580	0.17	570	1.75	568	2.11

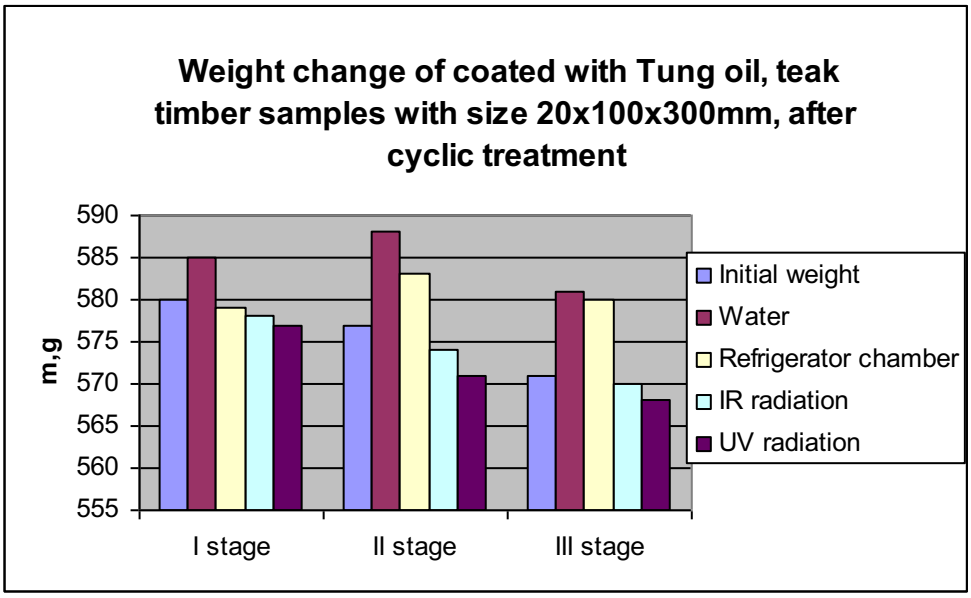


Fig. 6: Weight change of coated with Tung oil teak timber samples with size 20x100x300mm after cyclic treatment

Table 11: Weight change of coated with Teak oil teak timber samples with size 20x100x300mm after cyclic treatment

№ of stage	Initial weight	Water soaking – 24h		Refrigerator chamber – 48h		IR radiation – 12h		UV radiation – 12h	
	m g	m g	M_w %	M g	M_w %	m g	M_w %	m g	M_w %
I stage	553	561	1.45	555	1.08	553	0.36	553	0.36
II stage	553	567	2.53	566	0.18	554	2.17	550	2.91
III stage	550	564	2.55	561	0.53	545	2.94	543	3.31

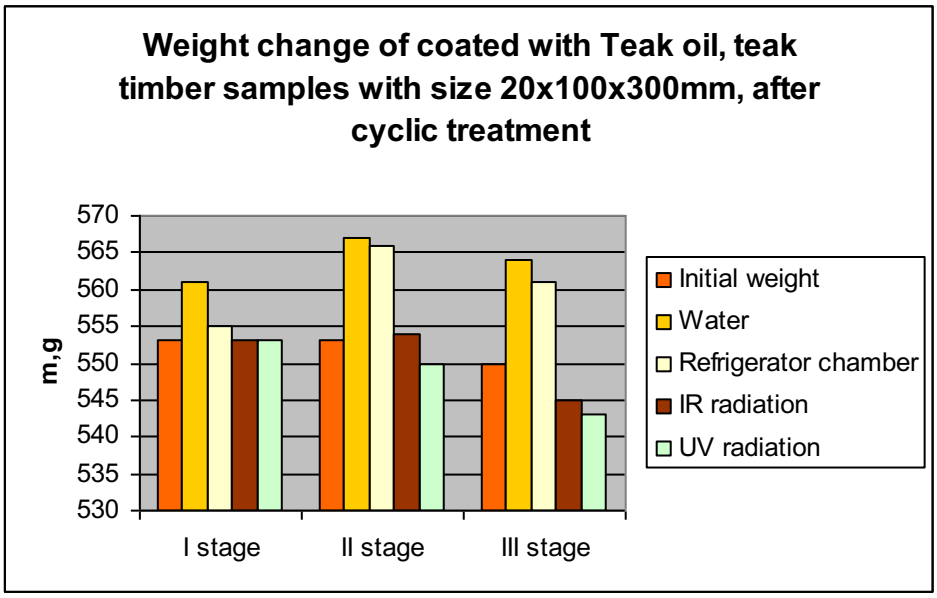


Fig. 7: Weight change of coated with Teak oil teak timber samples with size 20x100x300mm after cyclic treatment

Table 12: Weight change of coated with Valtti Oil, teak timber samples with size20x100x300mm, after cyclic treatment

№ of stage	Initial weight	Water soaking – 24h		Refrigerator chamber – 48h		IR radiation – 12h		UV radiation – 12h	
	m g	m g	M_w %	M g	M_w %	m g	M_w %	m g	M_w %
I stage	636	650	2.20	638	1.88	635	0.47	633	0.79
II stage	633	657	3.79	655	0.31	635	3.15	628	4.30
III stage	628	651	3.66	650	0.15	634	2.52	628	3.50

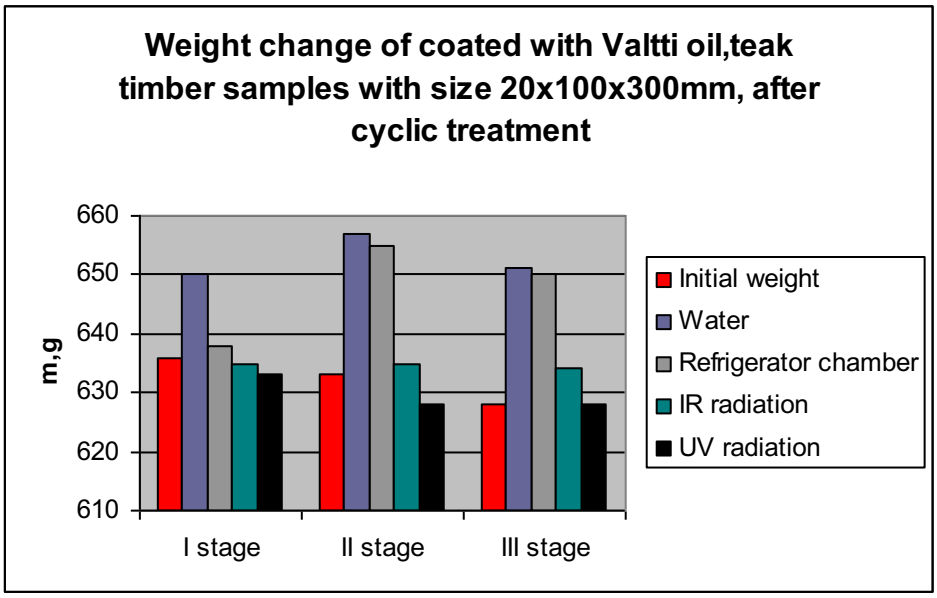


Fig. 8: Weight change of coated with Valtti Oil, teak timber samples with size 20x100x300mm, after cyclic treatment

In Table 13 and on Fig.9 is represented the information about change in weight of teak timber samples, treated with Yacht Varnish. After their soaking in tank with distillated water, where they should stay 24h and as a result of water absorption their weight increase (M_w = 2.29 %). The second step is stay of the samples in refrigerator chamber for 48h, the weight of samples decrease (M_w = 1.71 %). Third and fourth steps are irradiation of samples with IR and UV light, after that their weight decrease even more (M_w = 0.38 %; M_w = 0.57 %). There are 3 stages of timber treatment. At the beginning of second stage after the process of water soaking, flows have very clear manifesting.

In Table 14 and on Fig.10 is represented the information about change in weight of teak timber samples, treated with Vallti Exterior Wax. After their soaking in tank with distillated water, where they should stay 24h and as a result of water absorption their weight increase (M_w = 2.91 %). The second step is stay of the samples in refrigerator chamber for 48h, the weight of samples decrease (M_w = 2.32 %). Third and fourth steps are irradiation of samples with IR and UV light, after that their weight decrease even more (M_w = 0.19 %; M_w = 0.78 %). There are 3 stages of timber treatment At the beginning of third stage after the process of water soaking can be seen great amount of defects – coat rub off and cracks, due to water evaporation pressure and fundamental shrinkage (Y = 5.18 – 0.47- 0.16 %).

In Table 15 and on Fig.11 is represented the information about change in weight of teak timber samples, treated with Osmo Teak Oil. After their soaking in tank with distillated water, where they should stay 24h and as a result of water absorption their weight increase (M_w = 3.58 %). The second step is stay of the samples in refrigerator chamber for 48h, the weight of samples decrease (M_w = 2.71 %). Third and fourth steps are irradiation of samples with IR and UV light, after that their weight decrease even more (M_w = 0.42 %; M_w = 0.42 %). There are 3 stages of timber treatment. At the beginning of second stage after the process of water soaking appear an average amount of defects – coat rub off and cracks, due to water evaporation pressure and fundamental shrinkage (Y = 4.05 – 4.39- 4.06 %).

Table 13: Weight change of coated with Yacht Varnish, teak timber samples with size 20x100x300mm, after cyclic treatment

№ of stage	Initial weight	Water soaking – 24h		Refrigerator chamber – 48h		IR radiation – 12h		UV radiation – 12h	
	m g	m g	M_w %	M g	M_w %	m g	M_w %	m g	M_w %
I stage	524	536	2.29	527	1.71	525	0.38	524	0.57
II stage	524	542	3.44	537	0.93	520	3.27	518	3.67
III stage	518	536	3.47	533	0.56	521	2.30	517	3.09

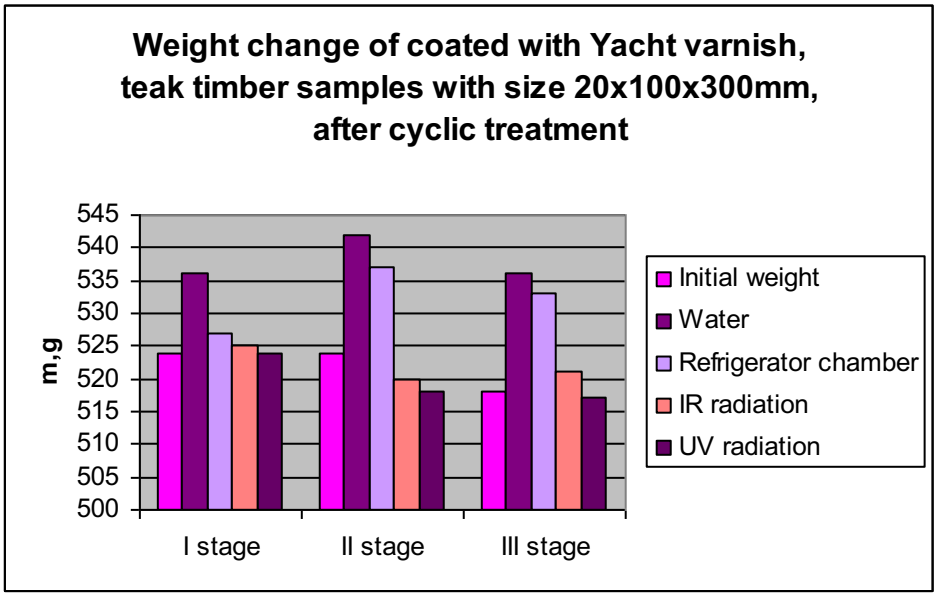


Fig. 9: Weight change of coated with Yacht Varnish teak timber samples with size 20x100x300mm after cyclic treatment

Table 14: Weight change of coated with Valtti Exterior Wax, teak timber samples with size 20x100x300mm, after cyclic treatment

№ of stage	Initial weight	Water soaking – 24h		Refrigerator chamber – 48h		IR radiation – 12h		UV radiation – 12h	
	m g	m g	M_w %	M g	M_w %	m g	M_w %	m g	M_w %
I stage	515	530	2.91	518	2.32	517	0.19	514	0.78
II stage	514	548	6.61	545	0.55	514	6.03	508	7.28
III stage	508	539	6.10	535	0.75	515	3.88	510	4.90

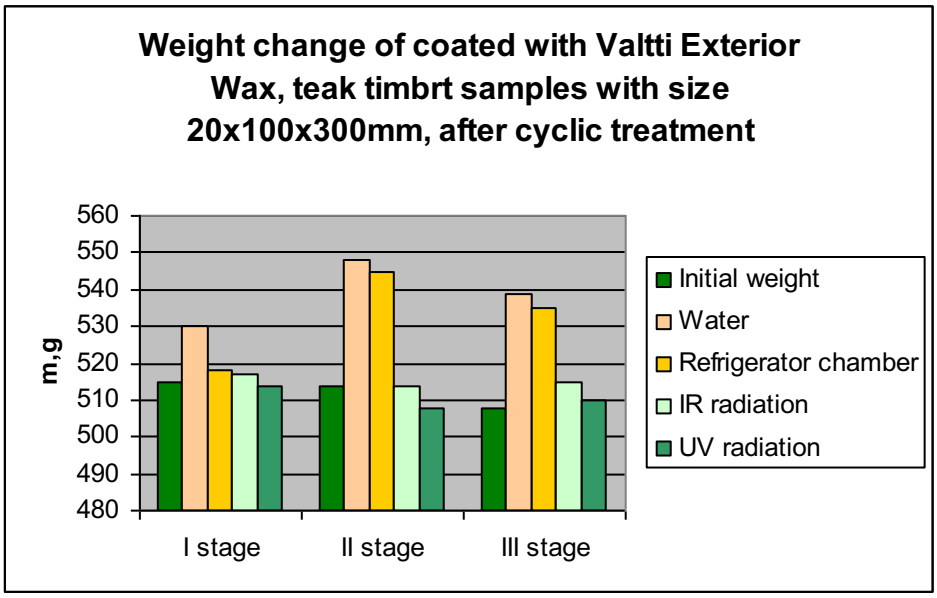


Fig. 10: Weight change of coated with Valtti Exterior Wax, teak timber samples with size 20x100x300mm, after cyclic treatment

Table 15: Weight change of coated with teak Osmo Teak Oil, teak timber samples with size 20x100x300mm, after cyclic treatment

№ of stage	Initial weight	Water soaking – 24h		Refrigerator chamber – 48h		IR radiation – 12h		UV radiation – 12h	
	m g	m g	M_w %	M g	M_w %	m g	M_w %	m g	M_w %
I stage	475	492	3.58	479	2.71	477	0.42	477	0.42
II stage	477	509	6.71	505	0.79	477	5.87	473	6.77
III stage	473	502	6.13	500	0.40	491	1.83	490	2.04

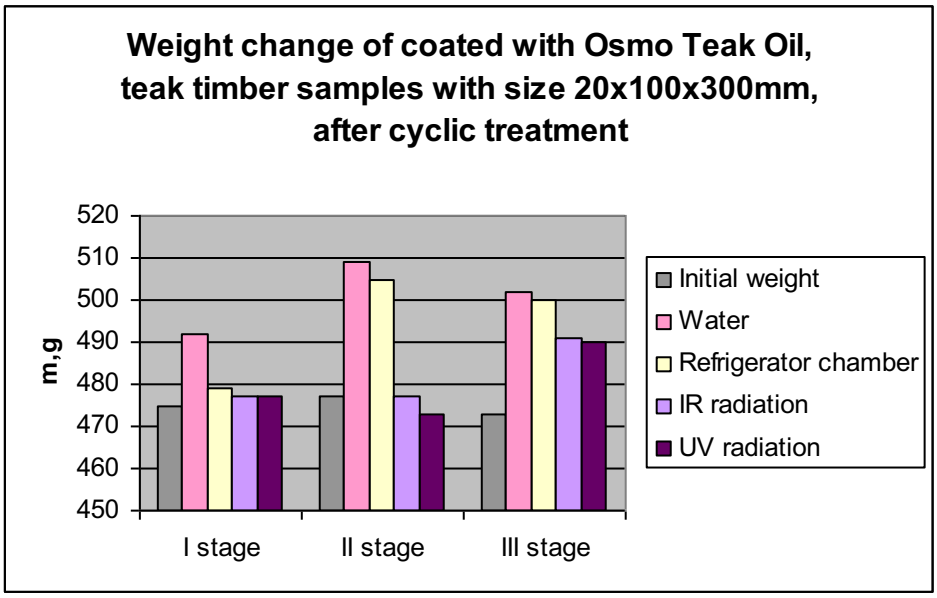


Fig. 11: Weight change of coated with teak Osmo Teak Oil, teak timber samples with size 20x100x300mm, after cyclic treatment

In Table 16 are shown the results of teak timber samples weight change after water absorption which are with size 20/50/300 mm. It can be clearly seen that water absorption is different for the different series. For example YV – Yacht Varnish after stage #1 the sample has absorbed 5.06% water, after stage #2 – 7.60 % and after stage #3 – 5.06 %. TgO – Tung Oil - after stage #1 the sample has absorbed 0.64 % water, after stage #2 – 1.35 % and after stage #3 – 0.99 %. After this water absorption samples have swollen in thickness, the results are shown in Table 17. There can be seen that samples' swelling is proportional to water absorption results. The greatest values of thickness swelling can be recognized in VEW series – after stage #1 is 1.36 – 0.84 – 1.58 %; after stage #2 is 2.03 – 1.31 – 1.89 % and after stage #3 is 2.59 – 1.26 – 1.32 %. The smallest values of thickness swelling can be seen in series treated with YV – Yacht Varnish - after stage #1 is 0.61 – 0.31 – 0.36 %; after stage #2 is 1.89 – 1.31 – 1.53 % and after stage #3 is 1.73 – 1.58 – 2.33 %. When talking about drying, the situation is similar (Table 18 and 19). The greatest shrinkage of samples is those of samples treated with Osmo Teak oil: Y = 4.05 – 4.39 – 4.06 % (Table 19).

In Table 20 and on Fig.12 is represented the information about change in weight of teak timber samples - size 20x50x300 mm, treated with tung oil. After their soaking in tank with distillated water, where they should stay 24h and as a result of water absorption their weight increase (M_w = 0.64 %).The second step is stay of the samples in refrigerator chamber for 48h, the weight of samples decrease (M_w

= 0.88 %). Third and fourth steps are irradiation of samples with IR and UV light, after that their weight decrease even more (M_w = 0.39 %; M_w = 0.48 %). There are 3 stages of timber treatment. At the end of third stage can be seen small amount of defects – coat rub off and cracks.

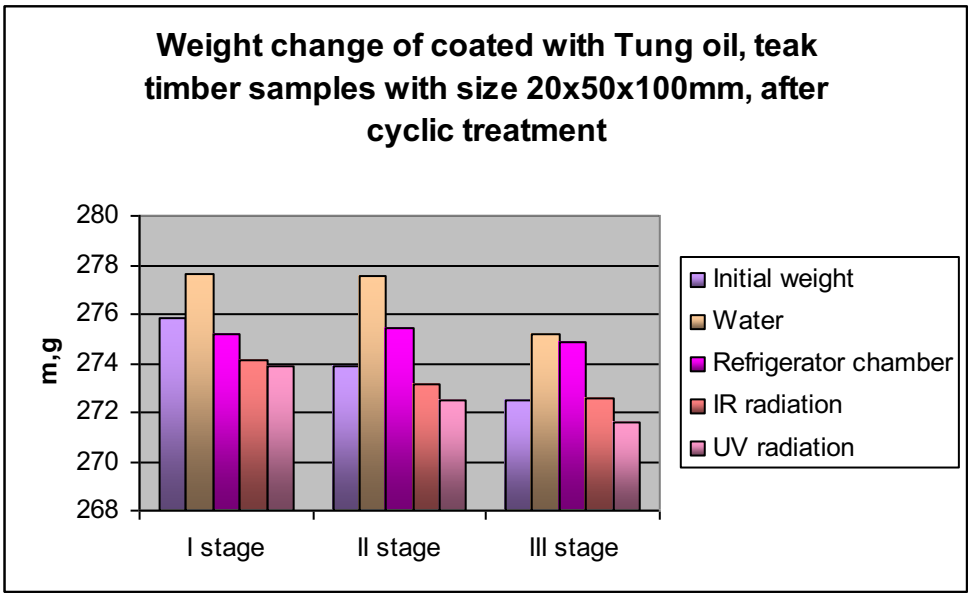


Fig. 12: Weight change of coated with Tung oil, teak timber samples with size 20x50x300mm, after cyclic treatment

Table 16: Teak timber sample weight change with size 20x50x300mm after water absorption

Index	Stage I			Stage II			Stage III		
	$M_o g$	M_f, g	M_w,%	$M_o g$	M_f, g	M_w,%	$M_o g$	M_f, g	M_w,%
TgO	275	277	0.64	273	277	1.35	272	275	0.99
TkO	267	272	2.05	265	276	4.03	261	271	3.79
VaO	220	231	4.89	219	236	7.73	218	233	6.99
YV	218	230	5.06	217	234	7.60	217	231	6.41
VEW	283	290	2.75	282	293	4.02	279	289	3.43
OTkO	285	292	2.46	284	294	3.42	283	291	2.74

Symbol: TgO –Tung oil; TkO –Teak oil; VaO - Valtti Oil; YV –Yacht Varnish;
VEW - Valtti Exterior Wax; OTkO - Osmo Teak Oil;

Table 17: Swelling of teak timber samples with size 20x50x300mm after water absorption

Index		Stage I			Stage II			Stage III		
		δ_o, mm	δ_f, mm	$H_\delta, \%$	δ_o, mm	δ_f, mm	$H_\delta, \%$	δ_o, mm	δ_f, mm	$H_\delta, \%$
TgO	δ_1	19.30	19.56	1.35	19.17	19.70	2.76	19.17	19.54	1.93
	δ_2	19.44	19.32	0.21	19.15	19.33	0.94	19.10	19.31	1.21
	δ_3	19.28	19.60	0.82	18.96	19.34	2.01	19.08	19.35	1.31
TkO	δ_1	19.20	19.40	1.04	19.25	19.64	2.03	19.13	19.69	2.93
	δ_2	19.34	19.38	0.41	19.23	19.40	0.88	19.04	19.47	2.26
	δ_3	19.30	19.55	1.09	19.29	19.49	1.04	19.16	19.79	3.29
VaO	δ_1	19.46	19.63	0.87	19.05	19.43	1.99	19.07	19.44	1.94
	δ_2	19.68	19.95	0.45	19.09	19.27	0.99	19.17	19.28	0.57
	δ_3	19.86	19.77	0.46	19.08	19.32	1.20	19.00	19.41	2.16
YV	δ_1	19.56	19.66	0.61	18.98	19.34	1.89	19.05	19.38	1.73
	δ_2	19.54	19.62	0.31	18.96	19.30	1.31	18.96	19.26	1.58
	δ_3	19.48	19.55	0.36	19.05	19.25	1.53	18.92	19.36	2.33
VEW	δ_1	19.88	20.15	1.36	18.88	19.26	2.03	18.85	19.34	2.59
	δ_2	19.08	19.24	0.84	18.99	19.30	1.31	19.08	19.32	1.26
	δ_3	19.02	19.32	1.58	19.05	19.35	1.89	18.99	19.24	1.32
OTkO	δ_1	19.50	19.58	0.41	19.03	19.39	1.89	18.96	19.47	2.69
	δ_2	19.80	19.75	0.25	19.01	19.17	0.84	19.16	19.34	0.94
	δ_3	19.70	19.89	0.45	19.04	19.22	0.95	19.03	19.25	1.16

Symbol: TgO –Tung oil; TkO –Teak oil; VaO - Valtti Oil; YV –Yacht Varnish;
VEW - Valtti Exterior Wax; OTkO - Osmo Teak Oil;

Table 18: Intermediate shrinkage of teak timber samples with size 20x100x300mm after cyclic treatment with IR and UV light

Index		Y,% - Stage I	Y,% - Stage II	Y,% - Stage III
TgO	δ_1	1,99	2,69	1,54
	δ_2	0,88	1,19	1,29
	δ_3	3,27	1,34	1,29
TkO	δ_1	0,77	2,60	2,84
	δ_2	0,77	1,86	1,75
	δ_3	1,33	1,69	2,83
VaO	δ_1	2,95	1,85	2,26
	δ_2	4,31	0,52	1,29
	δ_3	3,49	1,66	2,73
YV	δ_1	3,46	1,50	2,53
	δ_2	3,36	1,76	1,97
	δ_3	2,55	1,71	1,91
Table 18				
VEW	δ_1	6,30	2,13	2,53
	δ_2	1,30	1,14	1,71
	δ_3	1,40	1,86	1,30
OTkO	δ_1	2,81	2,22	3,90
	δ_2	3,75	0,52	2,12
	δ_3	4,27	0,99	2,82

Symbol: VEW - Valtti Exterior Wax; OTkO - Osmo Teak Oil;

Table 19: Final shrinkage of teak timber samples with size 20x100x300mm after cyclic treatment with IR and UV light

Index		δ_o, mm	δ_f, mm	Y, %
TgO	δ_1	19.30	19.24	0.311
	δ_2	19.44	19.06	1.955
	δ_3	19.28	19.10	0.934
TkO	δ_1	19.20	19.13	0.365
	δ_2	19.34	19.13	1.086
	δ_3	19.30	19.23	0.363
VaO	δ_1	19.46	19.00	2.364
	δ_2	19.68	19.03	3.303
	δ_3	19.86	18.88	4.935
YV	δ_1	19.56	18.89	3.425
	δ_2	19.54	18.88	3.378
	δ_3	19.48	18.99	2.515
VEW	δ_1	19.88	18.85	5.181
	δ_2	19.08	18.99	0.472
	δ_3	19.02	18.99	0.158
OTkO	δ_1	19.50	18.71	4.05
	δ_2	19.80	18.93	4.394
	δ_3	19.70	18.90	4.061

Symbol: TgO –Tung oil; TkO –Teak oil; VaO - Valtti Oil;
YV –Yacht Varnish; VEW - Valtti Exterior Wax; OTkO - Osmo Teak Oil;

Table 20: Weight change of coated with Tung oil, teak timber samples with size 20x50x300mm, after cyclic treatment

№ of stage	Initial weight	Water soaking – 24h		Refrigerator chamber – 48h		IR radiation – 12h		UV radiation– 12h	
	m g	m g	M_w %	M g	M_w %	m g	M_w %	m g	M_w %
I stage	275.85	277.608	0.64	275.193	0.88	274.097	0.39	273.872	0.48
II stage	273.872	277.565	1.35	275.395	0.79	273.107	0.84	272.494	1.06
III stage	272.494	275.209	0.99	274.839	0.13	272.554	0.84	271.569	1.20

In Table 21 and on Fig.13 is represented the information about change in weight of teak timber samples, treated with teak oil. After their soaking in tank with distillated water, where they should stay 24h and as a result of water absorption their weight increase (M_w = 1.94 %). The second step is stay of the samples in refrigerator chamber for 48h, the weight of samples decrease (M_w = 0.81 %). Third and fourth steps are irradiation of samples with IR and UV light, after that their weight de crease even more (M_w = 1.70 %; M_w = 1.71 %).There are 3 stages of timber treatment. At the end of second stage after UV radiation can be seen a huge amount of defects – coat rub off and cracks.

Table 21: Weight change of coated with Teak oil, teak timber samples with size 20x50x300mm, after cyclic treatment

№ of stage	Initial weight	Water soaking – 24h		Refrigerator chamber – 48h		IR radiation – 12h		UV radiation– 12h	
	m g	m g	M_w %	M g	M_w %	m g	M_w %	m g	M_w %
I stage	267.304	272.482	1.94	270.283	0.81	265.756	1.70	265.484	1.71
II stage	265.484	276.184	4.03	275.395	0.29	261.568	5.29	261.126	5.46
III stage	261.126	271.034	3.79	269.551	1.91	264.494	1.91	263.229	0.48

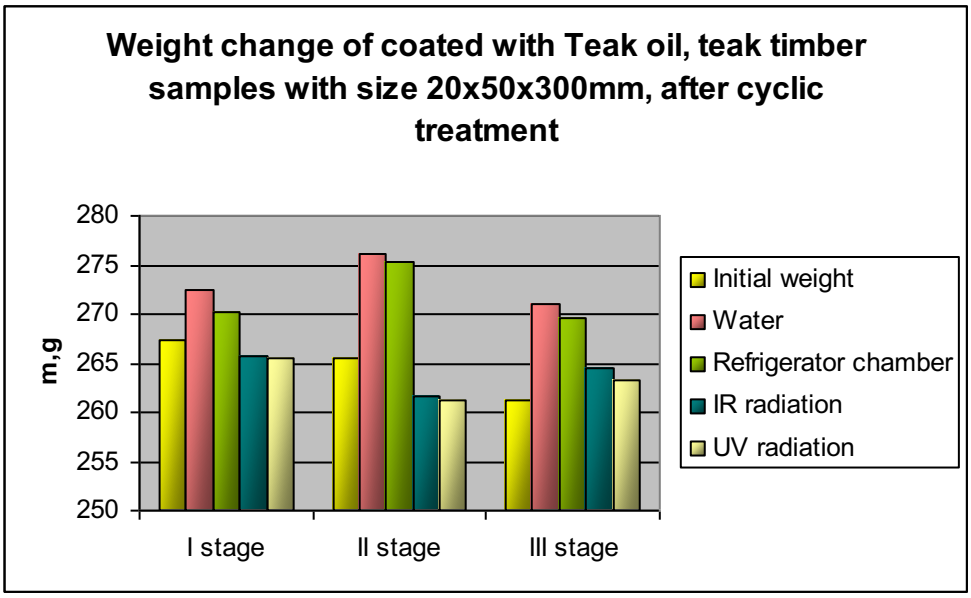


Fig. 13: Weight change of coated with Teak oil, teak timber samples with size 20x50x300mm, after cyclic treatment

In Table 22 and on Fig.14 is represented the information about change in weight of teak timber samples, treated with Vallti Oil. After their soaking in tank with distillated water, where they should stay 24h and as a result of water absorption their weight increase (M_w = 4.89 %). The second step is stay of the samples in refrigerator chamber for 48h, the weight of samples decrease (M_w = 0.41 %). Third and fourth steps are irradiation of samples with IR and UV light, after that their weight decrease even more (M_w = 4.39 %; M_w = 4.88 %). There are 3 stages of timber treatment. At the end of first stage can be seen small amount of defects – coat rub off and cracks.

In Table 23 and on Fig.15 is represented the information about change in weight of teak timber samples, treated with Yacht Varnish. After their soaking in tank with distillated water, where they should stay 24h and as a result of water absorption their weight increase (M_w = 5.06 %). The second step is stay of the samples in refrigerator chamber for 48h, the weight of samples decrease (M_w = 0.50 %). Third and fourth steps are irradiation of samples with IR and UV light, after that their weight decrease even more (M_w 4.30 %; 5.01 %). There are 3 stages of timber treatment. At the beginning of third stage after the process of water soaking can be seen small amount of defects – coat rub off and crack.

Table 22:Weight change of coated with Valtti Oil, teak timber samples with size20x50x300mm, after cyclic treatment

№ of stage	Initial weight	Water soaking – 24h		Refrigerator chamber – 48h		IR radiation – 12h		UV radiation– 12h	
	m g	m g	M_w %	M g	M_w %	m g	M_w %	m g	M_w %
I stage	220.539	231.324	4.89	230.377	0.41	220.833	4.32	219.65	4.88
II stage	219.65	236.638	7.73	234.415	0.95	220.947	6.09	218.128	1.29
III stage	218.128	233.382	6.99	231.458	0.81	217.865	6.24	216.838	0.47

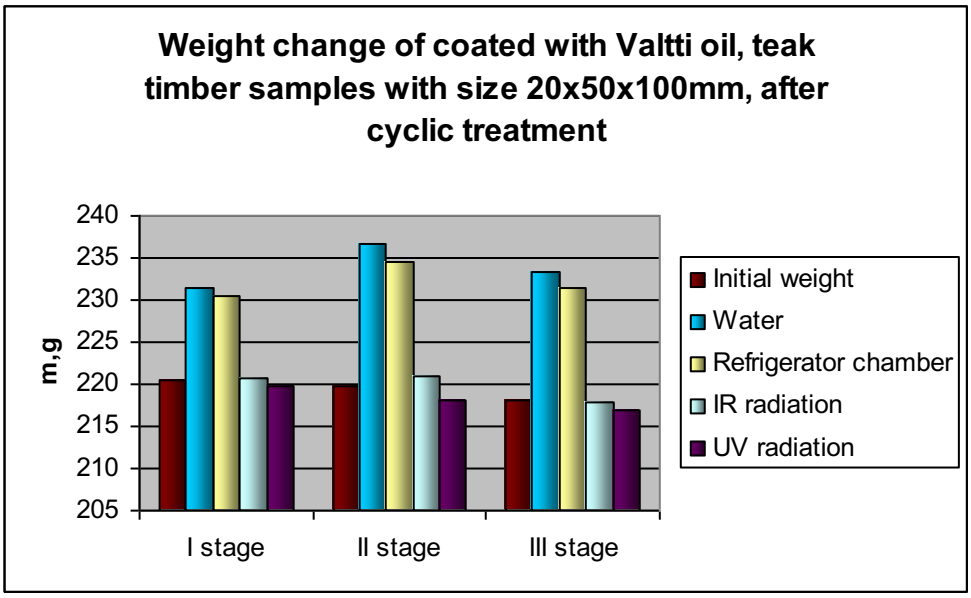


Fig. 14: Weight change of coated with Valtti Oil, teak timber samples with size20x50x300mm, after cyclic treatment

Table 23: Weight change of coated with Yacht Varnish, teak timber samples with size 20x50x300mm, after cyclic treatment

№ of stage	Initial weight	Water soaking – 24h		Refrigerator chamber – 48h		IR radiation – 12h		UV radiation– 12h	
	m g	m g	M_w %	M g	M_w %	m g	M_w %	m g	M_w %
I stage	218.974	230.051	5.06	228.902	0.50	219.455	4.30	217.972	5.01
II stage	217.972	234.54	7.60	233.478	0.45	222.45	4.96	217.355	7.42
III stage	217.355	231.294	6.41	230.136	0.50	216.813	6.14	215.285	6.89

In Table 24 and on Fig.16 is represented the information about change in weight of teak timber samples, treated with Vallti Exterior Wax. After their soaking in tank with distillated water, where they should stay 24h and as a result of water absorption their weight increase (M_w = 2.75 %). The second step is stay of the samples in refrigerator chamber for 48h, the weight of samples decrease (M_w = 0.68 %) . Third and fourth steps are irradiation of samples with IR and UV light, after that their weight decrease even more (M_w = 2.02 %; M_w = 2.32 %). There are 3 stages of timber treatment. At the beginning of first stage after the process of water soaking can be seen great amount of defects – coat rub off and cracks. At the beginning of third stage after appear a huge amount of flows.

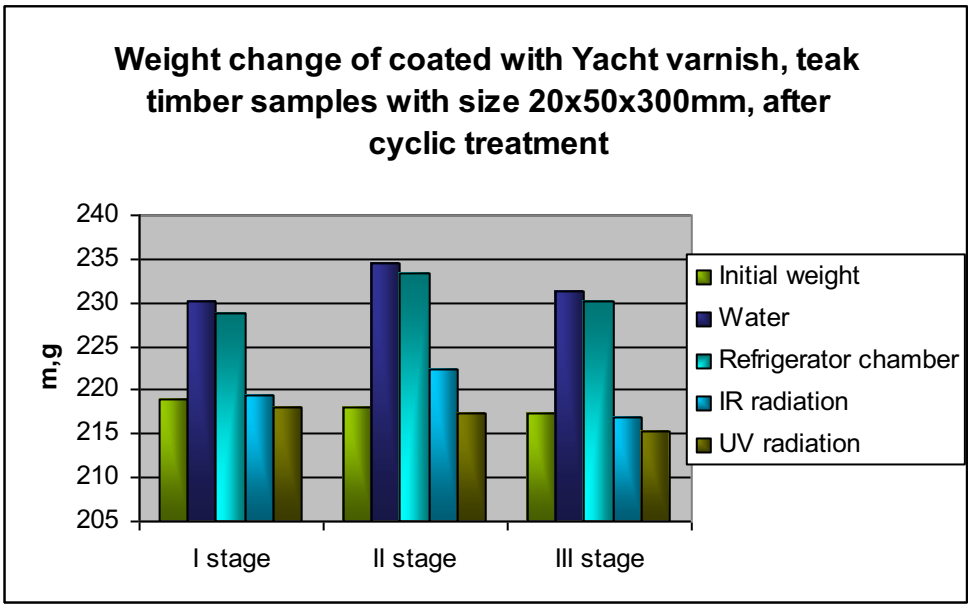


Fig 15: Weight change of coated with Yacht Varnish, teak timber samples with size 20x50x300mm, after cyclic treatment.

Table 24: Weight change of coated with Valtti Exterior Wax, teak timber samples with size 20x50x300mm, after cyclic treatment

№ of stage	Initial weight	Water soaking – 24h		Refrigerator chamber – 48h		IR radiation – 12h		UV radiation– 12h	
	m g	m g	M_w %	M g	M_w %	m g	M_w %	m g	M_w %
I stage	283.092	290.874	2.75	288.905	0.68	283.183	2.02	282.354	2.32
II stage	282.354	293.717	4.08	291.721	0.68	280.853	3.87	279.566	4.35
III stage	279.566	289.159	3.43	287.168	0.69	279.597	2.62	279.03	2.92

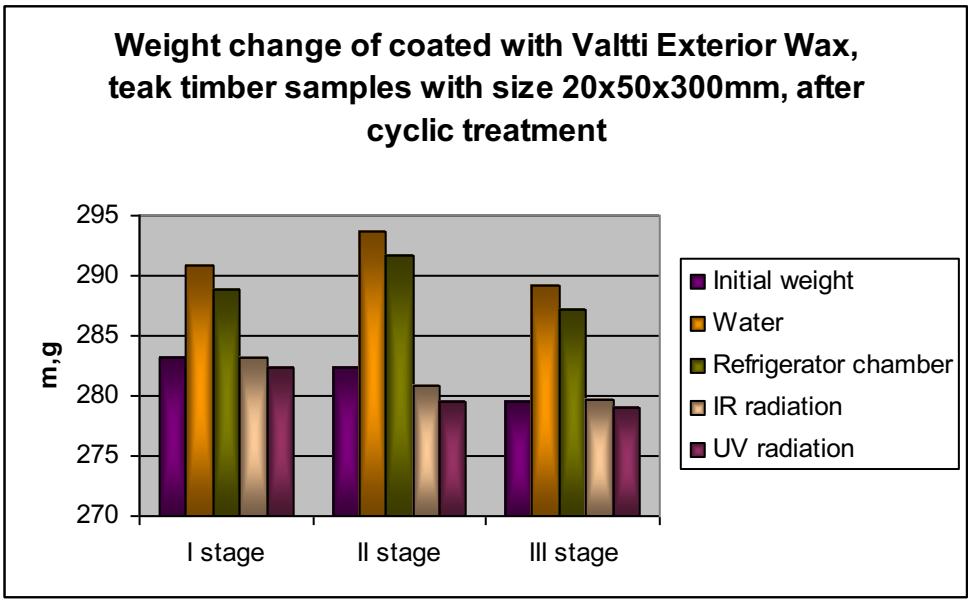


Fig. 16: Weight change of coated with Valtti Exterior Wax, teak timber samples with size 20x50x300mm, after cyclic treatment

In Table 25 and on Fig.17 is represented the information about change in weight of teak timber samples, treated with Vallti Exterior Wax. After their soaking in tank with distillated water, where they should stay 24h and as a result of water absorption their weight increase (M_w = 2.48 %). The second step is stay of the samples in refrigerator chamber for 48h, the weight of samples decrease (M_w = 0.15 %). Third and fourth steps are irradiation of samples with IR and UV light, after that their weight decrease even more (M_w = 2=14 %; 2.56 %). There are 3 stages of timber treatment. At the end of third stage after UV radiation appear an small amount of defects – coat rub off.

Table 25: Weight change of coated with teak Osmo Teak Oil, teak timber samples with size 20x50x300mm, after cyclic treatment

№ of stage	Initial weight	Water soaking – 24h		Refrigerator chamber – 48h		IR radiation – 12h		UV radiation– 12h	
	m g	m g	M_w %	M g	M_w %	m g	M_w %	m g	M_w %
I stage	285.415	292.422	2.48	291.985	0.15	285.864	2.14	284.708	2.56
II stage	284.708	294.432	3.42	292.295	0.73	285.212	2.48	283.311	3.17
III stage	283.311	291.078	2.74	290.022	0.36	280.523	3.39	280.057	3.56

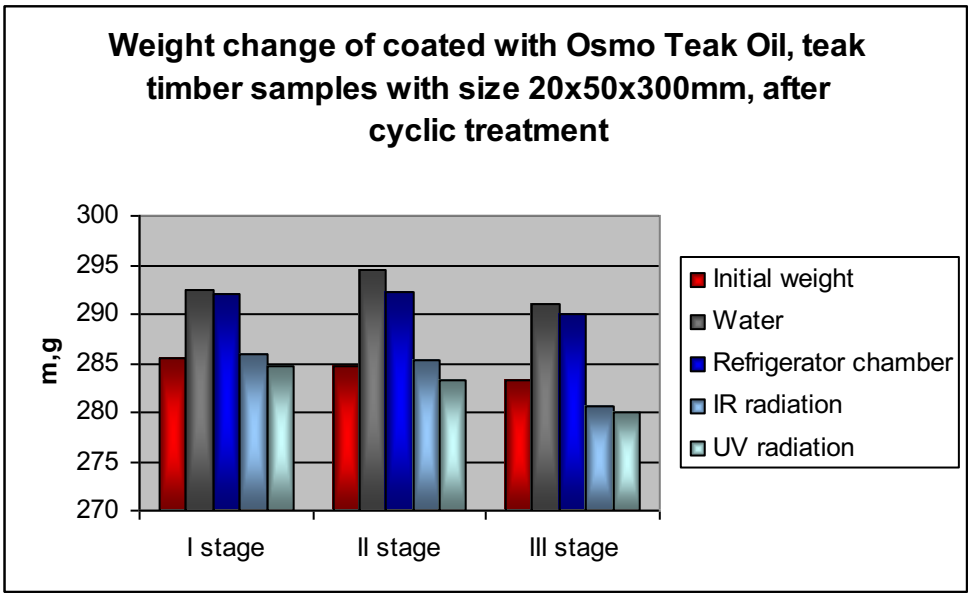


Fig. 17: Weight change of coated with teak Osmo Teak Oil, teak timber samples with size 20x50x300mm, after cyclic treatment

Outward appearance grade values of samples that have passed cyclic treatment is shown in Table 26. There is a numeral grade scale from "0 to 5" through which are being assessed condition s that can not be described in any other way. In Table 26 is shown grade value assessment of teak timber sample flows, which were coated with different types of varnishes. These samples have passed cyclic treatment – soaking in tank with distilled water, freezing in refrigerator chamber and radiation with IR and UV light. From the grade values in the table can be seen a tendency for increase of flow number over surface in the course of time. Appear different kinds of defects – cracks (due to the swelling and drying of samples), coat rub off (due to the accelerated weathering). Defects can be seen clearly when samples have been taken out of the refrigerator chamber.

Table 26: Flows assessment of teak timber samples that have passed cyclic treatment

Index	Stage I				Stage II				Stage III			
	1	*2*	*3*	*4*	*1*	*2*	*3*	*4*	*1*	*2*	*3*	*4*
1.1	1	1	1	1	2	2	2	3	3	4	4	4
1.3	1	1	1	1	1	2	2	2	2	2	2	2
2.2	0	0	1	1	1	1	2	2	2	2	2	2
3.1	1	2	2	2	2	3	3	3	3	3	3	3
3.3	1	2	2	2	2	3	3	3	4	4	4	4
4.2	0	1	1	1	1	2	2	2	2	2	2	2
5.3	0	1	1	1	1	1	1	1	1	2	2	2
5.5	1	2	2	2	2	2	2	3	3	4	4	4
6.3	0	1	1	2	2	2	2	2	2	2	2	2
7.3	0	0	1	1	1	1	1	1	2	2	2	2
8.3	0	1	1	2	2	3	3	3	3	3	3	3
8.5	0	0	0	1	1	1	1	1	1	1	1	2

Symbol: TgO –Tung oil; TkO –Teak oil; VaO - Valtti Oil;
YV –Yacht Varnish; VEW - Valtti Exterior Wax; OTkO - Osmo Teak Oil;

In Table 27 and on Fig.18 is represented the information about Teak timber coat adhesion. The results show that, the best adhesion to the surface have the coats formed with Tung oil - $\sigma_a = 6{,}37 N/mm^2$, the worst adhesion have the samples treated with Valtti Exterior Wax - $\sigma_a = 3{,}33 N/mm^2$. The difference between the two series is 3,04 N/mm² in favor of Tung oil coat. This difference is reliable, because the Gain of Student shows 7.45 >3. The results show that, the good adhesion to the surface have the coats formed with Valtti oil - $\sigma_a = 5.63 N/mm^2$ and with Yacht Varnish - $\sigma_a = 5.28 N/mm^2$

Table 27: Teak timber coat adhesion

Index	n	M_p	δ,	Variation indicators				
				Aver.	StD	Eror	V	p
	pieces	g/m²	µm	N/mm²	±N/mm²	±N/mm²	%	%
TgO	36	117	90	6.37	1.16	0.193	18.2	3.03
TkO	36	159	94	4.64	0.59	0.098	12.7	2.12
VaO	36	118	98	5.63	0.99	0.165	17.6	2.93
YV	36	116	95	5.28	0.81	0.135	15.3	2.56
VEW	36	124	101	3.33	0.85	0.142	25.5	4.25
OTkO	36	119	100	4.59	0.78	0.130	17.0	2.83

Table 28: Gain of Student

Index	TgO	VaO	TkO	YV	OTkO	VEW
TgO	-	1.702	4.621	2.672	4.445	7.45
VaO	1.702	-	2.979	0.938	2.873	6.233
TkO	4.621	2.979	-	2.215	0.193	4.547
YV	2.672	0.938	2.215	-	2.149	5.903
OTkO	4.445	2.873	0.193	2.149	-	3.901
VEW	7.45	6.233	4.547	5.903	3.901	-

Symbol: TgO –Tung oil; TkO –Teak oil; VaO - Valtti Oil;
YV –Yacht Varnish; VEW - Valtti Exterior Wax;
OTkO - Osmo Teak Oil;

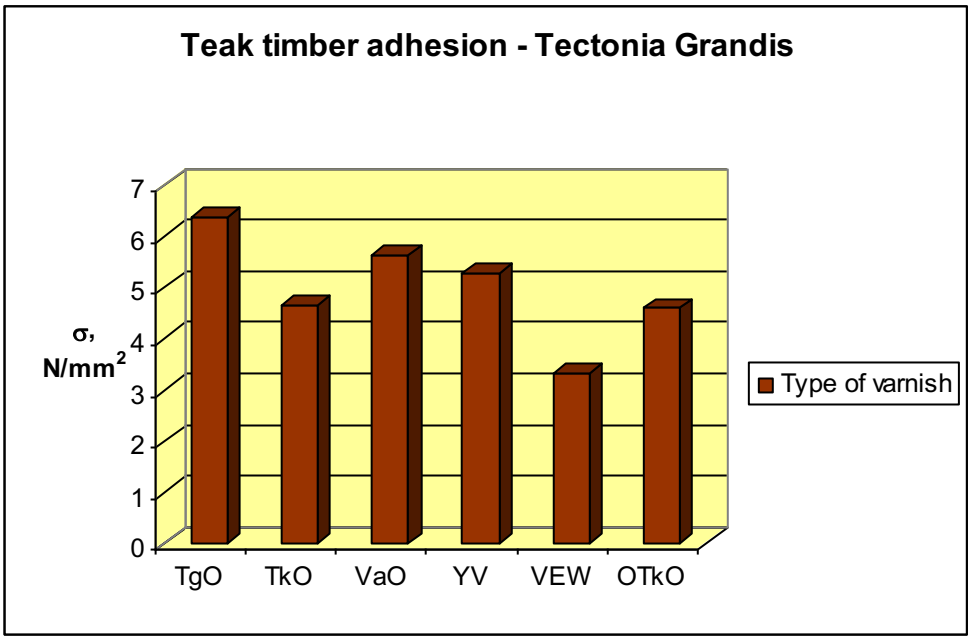


Fig. 18: Teak timber coat adhesion

The outward appearance of part of the treated with Valtti Exterior Wax samples is shown on Fig. 19



Fig.19: Samples treated with Valtti Exterior Wax

On Fig.20 is shown kinetics of sample weight change which are exhibited outdoor and treated with Tung oil. As time passes by the sample weight changes due to the weathering factors - rain, snow, fog, sun radiation. Between 0 – 144h and 528 – 552h the weather is cloudy there is a fog. The temperature varies from 8 to 15ºC, humidity is 55 -76%, sample weight increase. On the 312h of sample exhibition is snowing. The temperature is -1ºC, humidity is 100%. In the period between 144 – 192h and 408 – 432h the weather is cloudy and is raining. The temperature varies from 8 to 10ºC, humidity is 100%, sample weight increase sharply. Between 240 -264h and on the 480h the weather is sunny but very cold. The temperature varies from 3 to 12ºC, humidity is 36 -50%, sample weight

increase sharply. Sample weight and dampness decrease. On the 888h of sample exhibition the temperature is 10 ºC and humidity is 35%. This is due to the fact that part of the coat has rubbed off. On the 4320h (6 months) of sample exhibition their weight has visibly increased. The formed coat is in good condition.

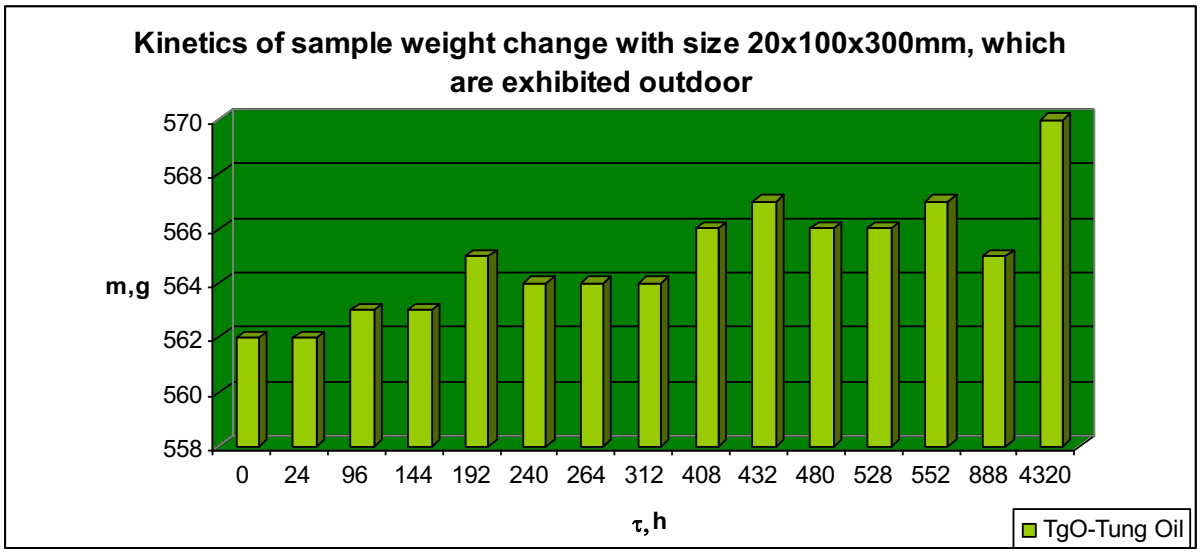


Fig. 20: Kinetics of sample weight change with size 20x100x300 mm, which are exhibited outdoor

On Fig.21 is shown kinetics of sample weight change which are exhibited outdoor and treated with Teak oil. As time passes by the sample weight changes due to the weathering factors - rain, snow, fog, sun radiation. Between 0 – 144h and 528 – 552h the weather is cloudy there is a fog. The temperature varies from 8 to 15ºC, humidity is 55 -76%, sample weight increase On the 312h of sample exhibition is snowing. The temperature is -1ºC, humidity is 100%. In the period between 144 – 192h and 408 – 432h the weather is cloudy and is raining. The temperature varies from 8 to 10ºC, humidity is 100%, sample weight increase sharply. Between 240 -264h and on the 480h the weather is sunny but very cold. The temperature varies from 3 to 12ºC, humidity is 36 -50%, sample weight increase sharply. Sample weight and dampness decrease.

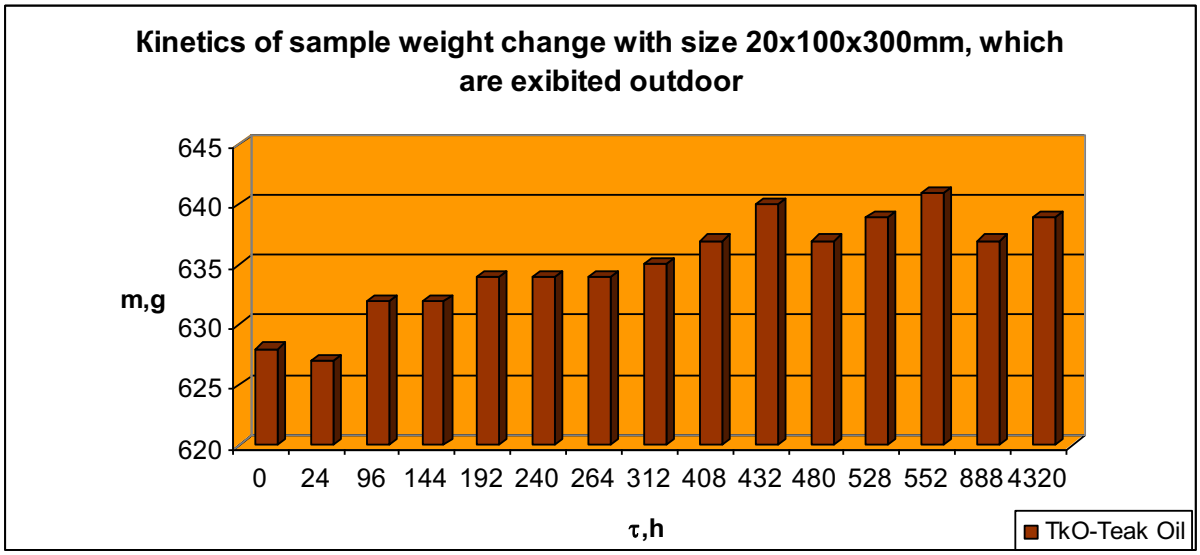


Fig.21: Kinetics of sample weight change with size 20x100x300 mm, which are exhibited outdoor

On the 888h of sample exhibition the temperature is 10 ºC and humidity is 35%. This is due to the fact that part of the coat has rubbed off. On the 4320h (6 months) of sample exhibition their weight has visibly increased. The formed coat is in very bad condition.

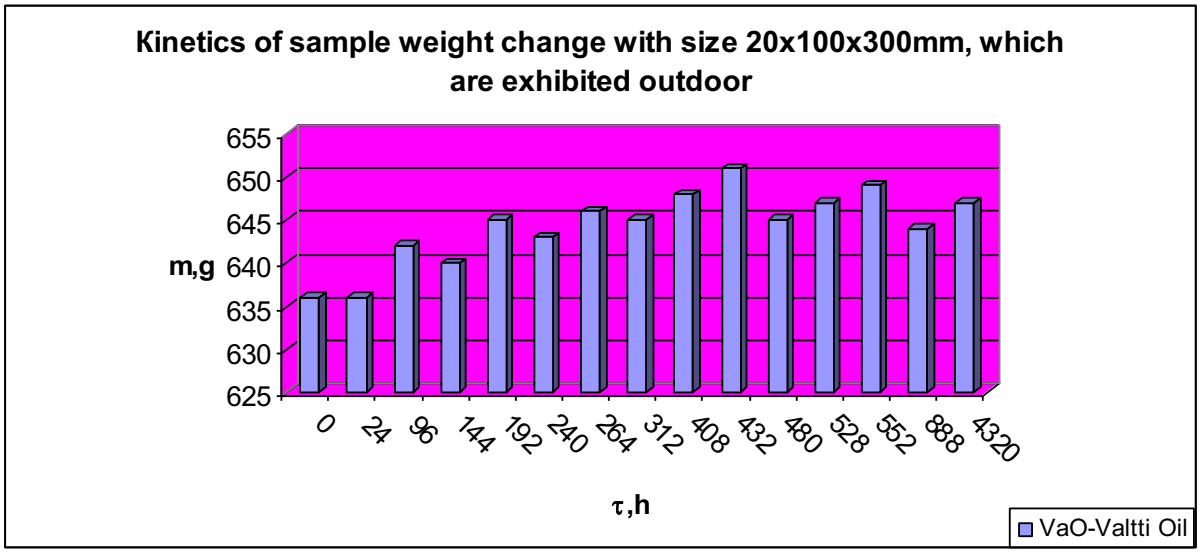


Fig.22: Kinetics of sample weight change with size 20x100x300 mm, which are exhibited outdoor

On Fig.22 is shown kinetics of sample weight change which are exhibited outdoor and treated with Valtti Oil. As time passes by the sample weight changes due to the weathering factors - rain, snow, fog, sun radiation. Between 0 – 144h and 528 – 552h the weather is cloudy there is a fog. The

temperature varies from 8 to 15ºC, humidity is 55 -76%, sample weight increase. On the 312h of sample exhibition is snowing. The temperature is -1ºC, humidity is 100%. In the period between 144 – 192h and 408 – 432h the weather is cloudy and is raining. The temperature varies from 8 to 10ºC, humidity is 100%, sample weight increase gradually. Between 240 -264h and on the 480h the weather is sunny but very cold. The temperature varies from 3 to 12ºC, humidity is 36 -50%, sample weight increase sharply. Sample weight and dampness decrease gradually. On the 888h of sample exhibition the temperature is 10 ºC and humidity is 35%. This is due to the fact that part of the coat has rubbed off. On the 4320h (6 months) of sample exhibition their weight has visibly increased. The formed coat is in good condition.

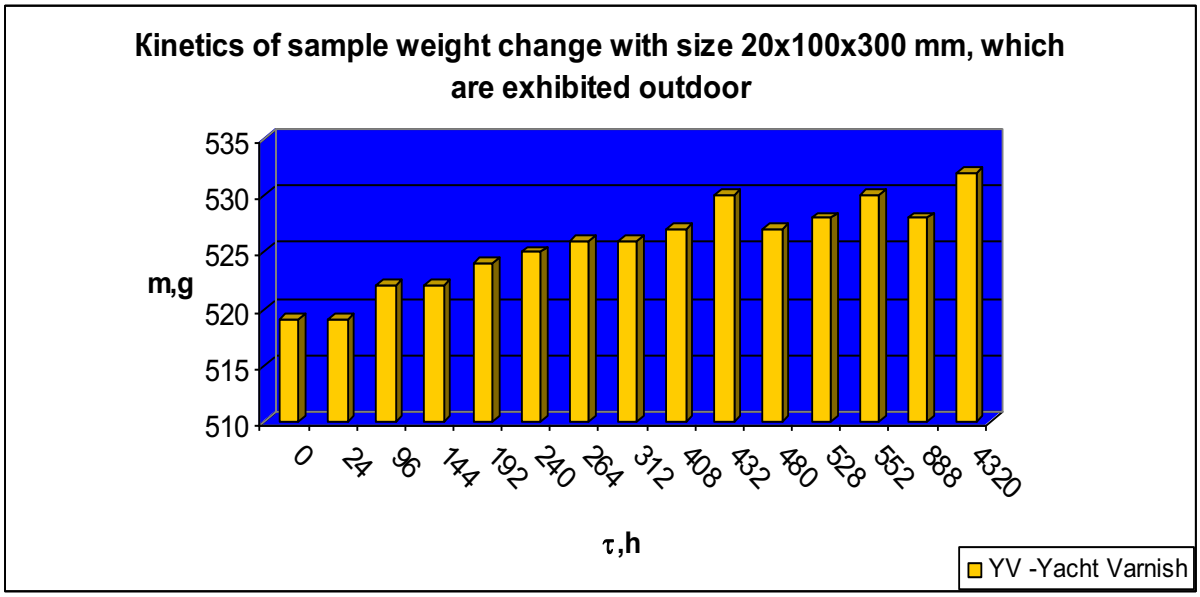


Fig.23: Kinetics of sample weight change with size 20x100x300 mm, which are exhibited outdoor

On Fig.23 is shown kinetics of sample weight change which are exhibited outdoor and treated with Yacht Varnish. As time passes by the sample weight changes due to the weathering factors - rain, snow, fog, sun radiation. Between 0 – 144h and 528 – 552h the weather is cloudy there is a fog. The temperature varies from 8 to 15ºC, humidity is 55 -76%, sample weight increase. On the 312h of sample exhibition is snowing. The temperature is -1ºC, humidity is 100%.In the period between 144 – 192h and 408 – 432h the weather is cloudy and is raining. The temperature varies from 8 to 10ºC, humidity is 100%, sample weight increase sharply. Between 240 -264h and on the 480h the weather is sunny but very cold. The temperature varies from 3 to 12ºC, humidity is 36 -50%, sample weight increase sharply. Sample weight and dampness decrease gradually. On the 888h of sample exhibition the temperature is 10 ºC and humidity is 35%. This is due to the fact that part of the coat has rubbed off. On the 4320h (6 months) of sample exhibition their weight has visibly increased. The formed coat is in bad condition.

On Fig.24 is shown kinetics of sample weight change which are exhibited outdoor and treated with Valtti Exterior Wax. As time passes by, the sample weight changes due to the weathering factors - rain, snow, fog, sun radiation. Between 0 – 144h and 528 – 552h the weather is cloudy and there is a fog. The temperature varies from 8 to 15ºC, humidity is 55 -76%, sample weight increase. On the 312h of sample exhibition is snowing. The temperature is -1ºC, humidity is 100%. In the period between

144 – 192h and 408 – 432h the weather is cloudy and is raining. The temperature varies from 8 to 10ºC, humidity is 100%, sample weight increase sharply. Between 240 -264h and on the 480h the weather is sunny but very cold. The temperature varies from 3 to 12ºC, humidity is 36 -50%, sample weight increase sharply. Sample weight and dampness decrease gradually. On the 888h of sample exhibition the temperature is 10 ºC and humidity is 35%. This is due to the fact that part of the coat has rubbed off. On the 4320h (6 months) of sample exhibition their weight has visibly increased. The formed coat is in bad condition.

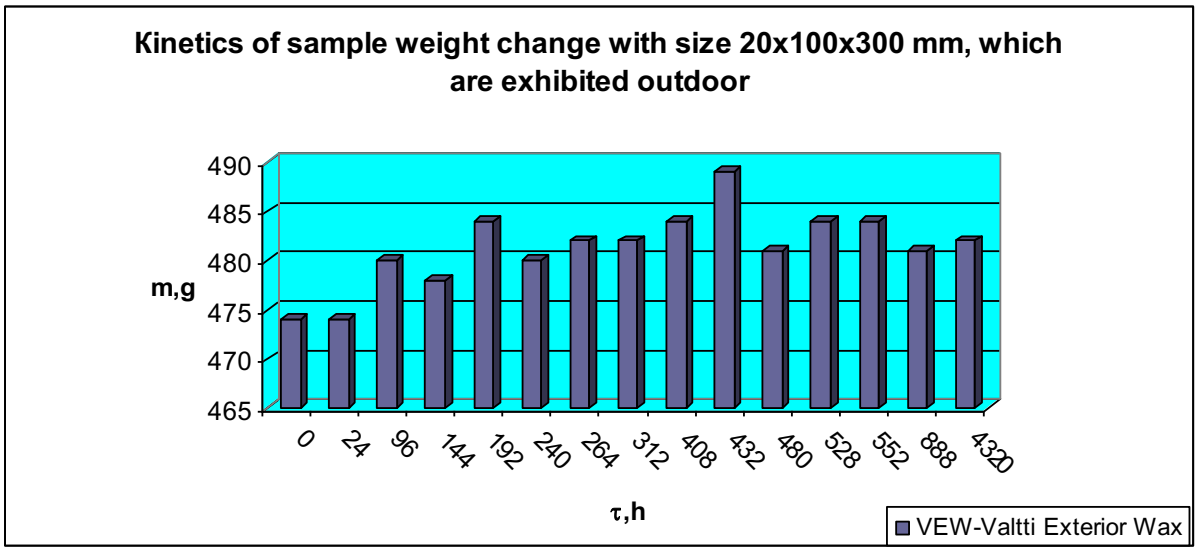


Fig.24: Kinetics of sample weight change with size 20x100x300 mm, which are exhibited outdoor

On Fig.25 is shown kinetics of sample weight change which are exhibited outdoor and treated with Osmo Teak Oil. As time passes by, the sample weight changes due to the weathering factors - rain, snow, fog, sun radiation. Between 0 – 144h and 528 – 552h the weather is cloudy there is a fog. The temperature varies from 8 to 15ºC, humidity is 55 -76%, sample weight increase. On the 312h of sample exhibition is snowing. The temperature is -1ºC, humidity is 100%. In the period between 144 – 192h and 408 – 432h the weather is cloudy and is raining. The temperature varies from 8 to 10ºC, humidity is 100%, sample weight increase sharply. Between 240 -264h and on the 480h the weather is sunny but very cold. The temperature varies from 3 to 12ºC, humidity is 36 -50%, sample weight increase sharply. Sample weight and dampness decrease gradually. On the 888h of sample exhibition the temperature is 10 ºC and humidity is 35%. This is due to the fact that part of the coat has rubbed off. On the 4320h (6 months) of sample exhibition their weight has visibly increased. The formed coat is in bad condition. For the need of the experiment in the yard of the University of Forestry – Sofia were exhibited teak timber samples. On Fig. 26 is shown the outward appearance of samples before their outdoor exhibition.

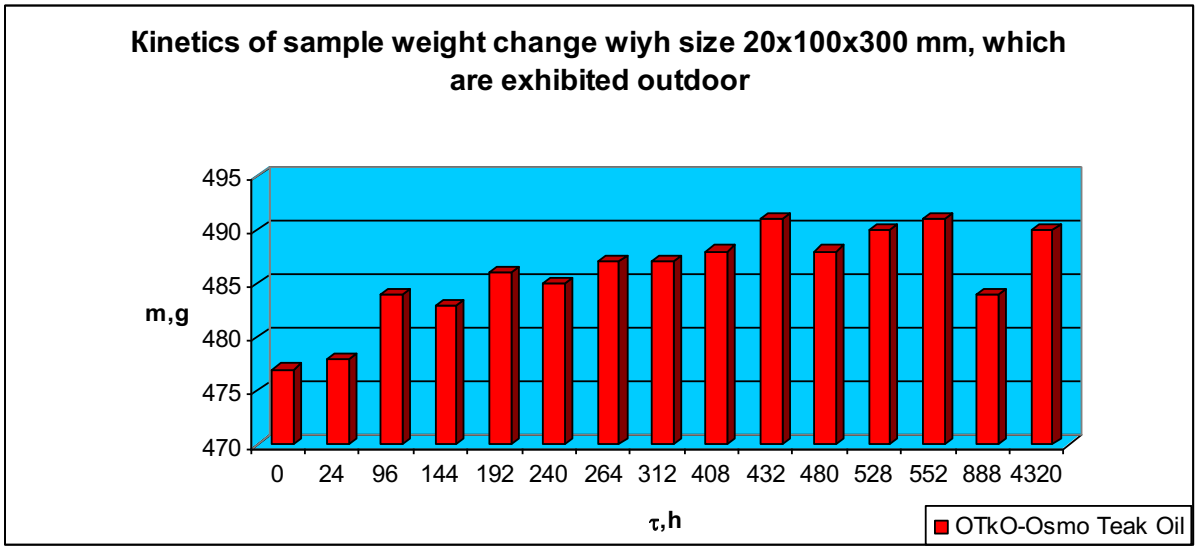


Fig.25: Kinetics of sample weight change with size 20x100x300 mm, which are exhibited outdoor



Fig. 26: Outward appearance of samples before their outdoor exhibition.

Fig. 27: Outward appearance of samples 6 mounts after their exhibition

For these 6 months of samples exhibition is observed coats' rubbing off , that was formed with Teak oil, Yacht Varnish, Osmo Teak Oil, Valtti Exterior Wax. On Fig. 27 can be seen the outward appearance of samples 6 mounts after their exhibition.

For assessment of coats evaporation degree that are exhibited outdoor, we can quote the already made analysis by virtue of which we have an idea of coats' condition, which have passed several stages of accelerated weathering that elapsed in controlled laboratory conditions. When estimating samples' weight change, swelling and drying can be made the following conclusions: 1).Coats formed with Tung oil and Valtti oil are not being influenced that much from water, temperature and UV radiation negative impact; 2). Samples treated with Tung oil and Valtti oil change their weight, swell and dry up to a small degree.

This is the reason why samples treated with Tung oil and Valtti oil which are exhibited outdoor keep their good outward appearance. Tropical timber is irreplaceable in decking production, for open terraces, verandas, decorations near pools, garden and park furniture, due to its has solidity. For continuous and problemless exploitation of teak timber furniture and floorings, they should be varnished 2 times in the year with high – grade products, otherwise the formed coating will be destroyed by the influence of the weathering factors.

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