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THE EFFECTS OF SEASONAL CHANGES ON THE COMBUSTION DURATION OF THE CEDAR (Cedrus libani A. Rich.) AND ORIENTAL SPRUCE (Picea Orientalis Lipsky) WOOD SAMPLES

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Abstract

In this study, the effects of the wood's combustion properties on the combustion duration are investigated towards the protection of the wood samples from the effects of outdoor by using various impregnation and high-level processes. For that purpose, in accordance with the given principles on the standard of combustion test ASTM–E 160-50 test samples from cedar (Cedrus libani A.Rich.) and spruce (Picea orientalis L.) are impregnated with tanalith-E and wolmanit-CB impregnation materials then water based and synthetic outdoor varnishes are applied as a high level process, afterwards seasonal effects on outdoor conditions are analysed.

According to the obtained findings, first failure time for spruce wood samples the peak is 457 seconds in winter and the minimum is 257 seconds in fall, for cedar wood samples the top time is 479 seconds and the minimum time is 326 seconds in winter samples. In all combustion durations, top time at spruce wood samples is 2105 seconds at control examples and minimum time is 1143 seconds in summer samples. For cedar wood samples the top time confirmed is 2707 seconds in fall samples and minimum time is 1338 seconds in summer examples

Keywords: Cedar Wood, Spruce Wood, Impregnate, Varnish, Combustion Duration

MEVSİMSEL DEĞİŞİMLERİN SEDİR (Cedrus libani A. Rich.) VE DOĞU LADİN (Picea Orientalis Lipsky) ODUN ÖRNEKLERİNİN YANMA DENEYİNDE YANMA SÜRELERİNE ETKİSİ

Özet

Bu çalışmada, odun örneklerinin dış ortamda etkilerinden korunmasına yönelik çeşitli emprenye ve üst yüzey işlemleri uygulanarak odunun yanma özelliklerinden yanma süreleri üzerindeki etkileri araştırılmıştır. Bu amaçla, ASTM–E 160-50 yanma testi standartlarında verilen esaslara göre sedir (Cedrus libani A.Rich.) ve ladin (Picea orientalis L.) odunundan hazırlanan deney örnekleri ASTM–D 1413–76 esaslarına göre tanalith-E ve wolmanit-CB emprenye maddeleri ile emprenye edilip ASTM-D 3023 esaslarına göre üst yüzey işlemi olarak sentetik ve su bazlı dış mekan vernikleri uygulandıktan sonra açık hava şartlarında mevsimsel etkileri incelenmiştir.

Elde edilen sonuçlara göre, ilk yıkılma süresi; Ladin odunu örnekleri için en yüksek kış örneklerinde 457 sn ve en düşük ise sonbahar örneklerinde 257 sn, Sedir odunu örnekleri için en yüksek kontrol örneklerinde 479 sn, en düşük ise kış örneklerinde 326 sn'dir. Tüm yanma süresinde ise; Ladin odunu örnekleri için en yüksek kontrol örneklerinde 2105 sn ve en düşük ise yaz mevsimi örneklerinde 1143 sn, Sedir odunu örnekleri için en yüksek sonbahar örneklerinde 2707 sn, en düşük ise yaz mevsimi örneklerinde 1338 sn olarak tespit edilmiştir.

Anahtar Kelimeler: Sedir Odunu, Ladin Odunu, Emprenye, Vernik, Mevsimsel Değişim, Yanma Süresi,

1 Introduction

Wood material is widely used in interior and exterior decoration thanks to having characteristics like being aesthetic, being light, easy processability, superior physical and mechanical features in comparison with the other construction materials. However together with these positive features, it has characteristics like resulting in physical and mechanical changes under the exterior effects besides being flammable which limit the usage areas. Effects like loss of the radiance, rub surface, crack formation and colour change in wood surface, which are connected to the chemical changes in the structure of cellulose, hemicellulose, and lignin, the main components used in wood material under the outdoor environment conditions, are seen. This progress hosts quite complex reaction in its structure [1].

Wolmanit – CB as well as being a substance used as the protective against fire, impregnated wood material burns fairly harder than the normal wood material. In its combination there is %35 copper sulphate ($CuSO_4$). $5H_2O$), %45 potassium bichromate ($K_2Cr_2O_7$), %20 boric acid (H_3BO_3). Having no arsenic flour substances in its content has reduced its poisonous impact on humans and animals. It has projective effect against the insects, fungus ruining the wood, vermin destroying the wood in sea water including fungus causing soft rottenness. [2].

The various impacts of impregnation substance used for the purpose of protecting eucalyptus wood in interior and exterior environment (biotic and abiotic factors) on combustion features are investigated and tanalith-CBC, borax, boric acid, vacsol-WR, immersol-WR, polietilenglikol-400 and ammonium sulphate are used as impregnation. Consequently, compounds with salt and boron increased the combustion resistance of the wood, increasing effects of water driving substances are reduced [3].

Wood based sheets' combustion resistance is investigated. During the experiment, applying with a flush and dipping techniques, 2K2CO3.3H2O, Na2B4O7.10H2O and wolmanit-CB substance along with plywood, OSB, MDF sheets are used. It is identified that Wolmanit-CB chemical whose starting time for combustion identified latest, has the longest duration for flaming combustion. According to this, it can be said that wolmanit is a substance that blazes late but vulnerable to combustion, it has an increasing effect for its long flaming combustion which is longer than the control pieces [4].

Mechanical strength losses of samples impregnated with borax were lower than non-impregnated controls and specimens impregnated with boric acid [5].

Varnishes showed an increasing impact and boron compounds showed decreasing impact on combustion [6].

A research is done to determine impact of colour opening operation the combustion features of varnishes and wood samples. In respect to this study we can say that colour opening operation and colour opening solutions has lowered the increasing effect for combustion, decreased smoke density, shortened the combustion duration and given results close to control. Gas values were close or equivalent to control values expect for CO, whose values were high [7].

2 Experiment

2.1 Materials

Cedar and oriental spruce woods, which is frequently employed in the wood processing industry in Turkey, was selected as the material. The wood material was obtained in a randomized manner from a timber processing plant in Trabzon in compliance with TS 2476, taking care to sample healthy, regular-fibred, rot-free, knot-free, normally grown pieces without any reaction wood and devoid of fungal and insect attacks [8]. The preparation of samples Gumushane University Vocational School was conducted in the workshop furniture and decoration applications.

Two frequently employed impregnation chemicals, wolmanit-CB and tanalith-E were used to impregnate the samples. Water-based varnish was selected owing to the fact that its chemical formulation lacks volatiles while synthetic varnish was selected because of its regular use in Turkey.

2.2 Methods

2.2.1 Preparation of the test samples

Experiment samples for the study are prepared from clean, crack-free, proper wire formation, straight fibered pieces without resin and growth detects, and sharp wood parts without color and density differences, unharmed from any insect or fungus activity and without reaction wood.

The experimental samples were regularly cut in sizes of 13x13x76 mm (radial x tangent x length). A total of 6480 test samples were prepared from cedar and oriental spruce woods to investigate the effect of 2 different impregnating materials, 2 different types of varnish, 4 seasons and for the investigation of samples with 3 groups, with 24 samples in each group (2x5x3x3x24x3). The test samples were dried at 20±2ºC and a relative humidity of 65±5 % until they reached constant weight prior to any treatment application and they were weighed to a precision of 0.01 g [9].

Table 1. Test samples prepared for the present study.

Wood Type	Factor			Number
	Change of seasonal	Materials of impregnate	Types of varnish	
Cedar	Spring	Wolmanit-CB	Water-based varnish	3x24=72
	Summer			3x24=72
	Fall			3x24=72
Oriental Spruce	Winter	Tanalith-E	Synthetic varnish	3x24=72
	Control			3x24=72

2.2.2 Impregnation

The vacuum-pressure method was employed for impregnation as detailed in ASTM-D 1413-76. The impregnated materials were left in an air-circulated room for 15-20 days to allow for the evaporation of the solvent material and were kept at a temperature of 20±2°C and relative humidity of 65±3 % until they achieved constant moisture content of 12 % [10].

2.2.3 Determination of the extent of retention

The extent of retention of the impregnating material of the test samples was determined as provided in the TS 5724, 1988 standard and was calculated making use of the values prior to and post-impregnation using the following equation [11].

The retention of the samples used in the experiments is provided in Table 2.

$$R = \left[\frac{G.C}{V}\right] \times 1000 \text{ kg/m}^3 \qquad (1)$$

where; $G = T_2 - T_1$
T_1= sample weight prior to impregnation (g),
T_2= sample weight post impregnation (g),
V= sample volume (cm^3),
C= concentration of the solution (%)

Table 2. Extent of retention of the test samples used in the experiments.

Retention (kg/m³)	
Wolmanit-CB	Tanalith-E
2.48	1.26

2.2.4 Varnish application

The samples were varnished following impregnation and acclimatization in compliance with the principles provided in ASTM-D 3023, 1988 [12]. Sample surfaces were lightly sanded using no. 220 sandpaper and cleaned of dust to make them ready for varnish application. Manufacturer's recommendations on the amount of varnish to be applied were followed. The varnish was weighed on a scale with a precision of 0.01 g. The amount of hardeners, thinners or diluting media needed to condition the varnish were employed in compliance with the recommendations of the manufacturer. The varnished samples were dried at room temperature.

2.2.5 Outdoor Exposure

Both the control (untreated) samples and the varnished and impregnated samples were then left outdoors on stands that were prepared according to the ASTM G7-05 standard between 06/01/2012 – 05/31/2013 [13]. The meteorological parameters for Ankara during the period of June 2012 - May 2013 are displayed in Table 2.

Table 3. Meteorological Data for Ankara During the Period of June 2012-May 2013

ANKARA	
Average of temperature (°C)	14.8
Average of the highest temperature (°C)	28.1
Average of the lowest temperature (°C)	3.4
Monthly maximum rainfall (mm)	9.8
Monthly average relative humidity (%)	57.4
Monthly average Daily total sunbath (hours)	5.8

2.2.6 Combustion tests

The impregnated - non-impregnated and varnished - unvarnished samples were removed from the outdoor environment at the end of their periodic exposure and the ignition characteristics of the samples were determined using the apparatus as detailed in the ASTM-E 160–50, 1975 standard [14].

2.2.7 Statistical evaluation of the data

The temperature of combustion process, the illuminance, the duration of combustion, the weight loss and the results of the gas analyses of the samples measured in triplicate were used to conduct an analysis of variance employing randomized block factorial experimental design using SAS software. The mean values were compared using the least significant difference (LSD) test.

Finally, the multiple correlation analysis was carried out in order to investigate the relationship between groups, SAS 1989 [15].

3 Conclusion

According to wood average values for first destruction time, spruce samples are lowest with 355,83 seconds, cedar samples are highest with 432,5 3 seconds; at the same time, all average time for combustion duration, the highest time belongs to cedar samples with 189,52 seconds, the lowest time belongs to spruce samples with 1576,23 seconds (table 4). In respect to wood species, the average values for first destruction and complete combustion period are given in the Figure 1.

Table 4. The average values for first destruction and complete combustion duration according to wood types and groups obtained from least significant difference (LSD) test

Wood Type	Time of Demolition First (seconds)	Time of All Burn (seconds)
Cedar	432,53	1892,52
Spruce	355,83	1576,23
Average	394,18	1734,38
Sx	54,24	223,65
CV (%)	0,14	0,13

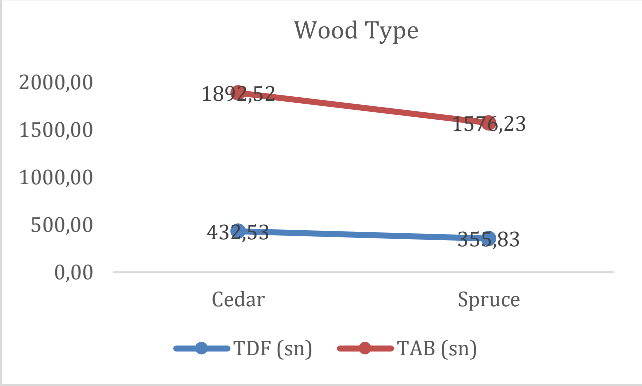

Figure 1. The average values for first destruction and complete combustion duration according to wood types and groups obtained from least significant difference (LSD) test

While the analyses for average first destruction time are shown in the Table 5 according to the impregnated substance, highest value is 405,17 seconds in non-impregnated, the lowest value is 387,48 seconds in samples impregnated with wolmanit CB; average numbers of the complete combustion period figure out as following; the highest value is 1950,70 seconds in impregnated with wolmanit-CB, the lowest one is 1513,38 seconds in non-impregnated samples. (Fig 2).

Table 5. The average values for first destruction and complete combustion duration according to impregnation substance and groups obtained from least significant difference (LSD) test

Materials of impregnate	Time of Demolition First (seconds)	Time of All Burn (seconds)
Wolmanit-CB	387,48	1950,70
Tanalith-E	389,91	1739,05
Control	405,17	1513,38
Average	394,18	1734,38
Sx	9,59	218,70
CV (%)	0,02	0,13

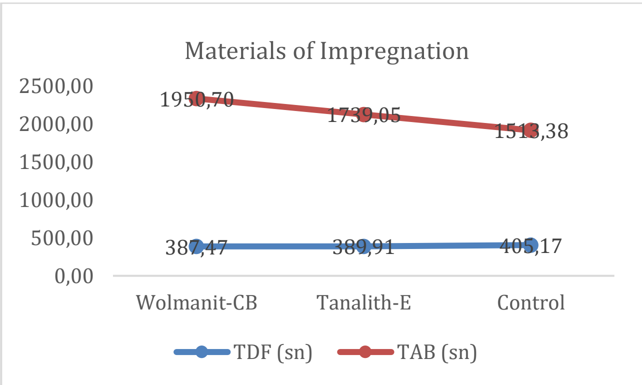

Figure 2. The average values for first destruction and complete combustion duration according to impregnation substance and groups obtained from least significant difference (LSD) test

According to varnish types, among average values of the first destruction durations 403,00 seconds is the highest in water based varnished samples, 389,62 seconds is the lowest value in synthetic varnished; average values for complete combustion duration measured highest with 1526,07 seconds in water based varnished samples, measured lowest with 1459,27 seconds in synthetic varnished samples.

Table 6. The average values of first destruction and complete combustion duration according to varnish types and groups obtained from least significant difference (LSD) test

Types of varnish	Time of Demolition First (sn)	Time of All Burn (sn)
Water-based	403,00	1526,07
Synthetic	389,62	1459,27
Control	389,92	1749,88
Average	394,18	1734,38
Sx	7,64	13,50
CV (%)	0,02	0,01

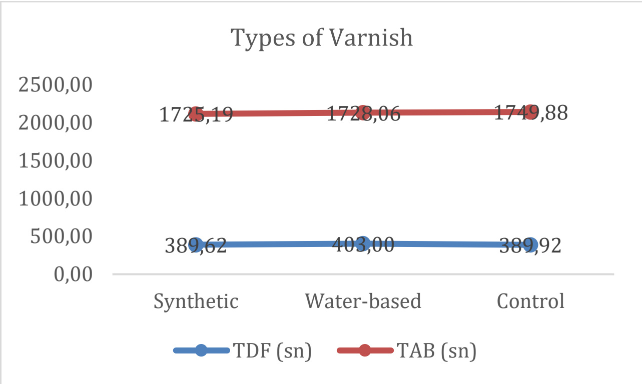

Figure 3. The average values of first destruction and complete combustion duration according to varnish types and groups obtained from least significant difference (LSD) test

According to seasonal changes, while average first destruction periods (Table 7) were determined highest in summer samples with 436,89 seconds, lowest in spring samples with 361,91; complete combustion periods showed the highest value in fall samples which is 2176,19 seconds, the lowest value in spring samples which is 1240,83 seconds (Figure 4).

Table 7. According to seasonal changes average values of first destruction periods and groups obtained from least significant difference (LSD) test

Change of seasonal	Time of Demolition First (seconds)	Time of All Burn (seconds)
Summer	407,89	1240,83
Fall	372,61	2176,19
Winter	391,61	1877,52
Spring	361,91	1417,37
Control	436,89	1959,96
Average	394,18	1734,37
Sx	29,69	213,39
CV (%)	0,08	0,47

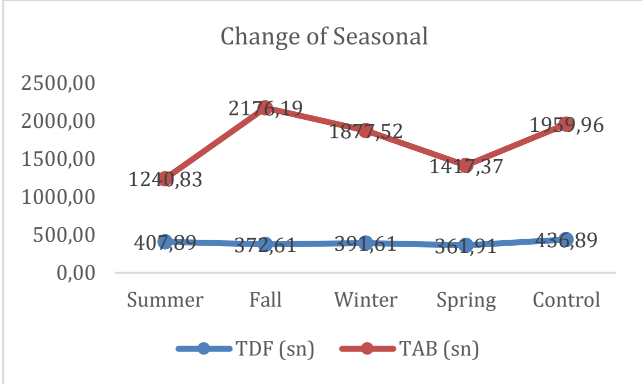

Figure 4. According to seasonal changes average values of first destruction periods and groups obtained from least significant difference (LSD) test.

Average values of first combustion duration in respect to seasonal change, wood type, varnish types and impregnation substance interaction, measured 658,33 seconds as highest value in cedar summer samples impregnated with Tanalith-E and varnished with synthetic varnish; 204 seconds as lowest value in spruce spring samples applied with synthetic varnish and non-impregnated. Complete combustion duration according to seasonal change, varnish types, wood type and impregnation substance interaction on average is highest with 3846 seconds in cedar fall samples impregnated with Wolmanit-CB and varnished with synthetic varnish; is lowest with 690 seconds in spruce summer samples non-impregnated covered with synthetic varnish (Table 8).

Table 8. Average values of first destruction and complete combustion durations according to seasonal change, varnish types, wood type and impregnation substance interaction

Change of seasonal*Wood type *Materials of impregnate * Types of varnish	TDF (sn)	Error	TAB (sn)	Error
Summer* Spruce*Wol-CB*Syn	405	105	990	30
Summer* Spruce*Wol-CB*Wb	420	90	1455	135
Summer* Spruce* Wol-CB*Con	345	75	990	30
Summer* Spruce*Tan-E*Syn	345	30	1470	30
Summer* Spruce*Tan-E*Wb	340,33	35,02	1085	85
Summer* Spruce*Tan-E*Con	525	30	1455	285
Summer* Spruce* Con*Syn	255	15	690	120
Summer* Spruce* Con*Wb	267,67	57,50	1020	30
Summer* Spruce* Con*Con	375	15	1135	115
Summer* Cedar *Wol-CB*Syn	345	15	1230	120
Summer* Cedar *Wol-CB*Wb	358,67	16,50	1320	120
Summer* Cedar *Wol-CB*Con	367,67	7,50	1140	210
Summer* Cedar *Tan-E*Syn	658,33	241,50	1560	0
Summer* Cedar *Tan-E*Wb	420	30	1755	165
Summer* Cedar *Tan-E*Con	426,67	38,50	1410	90
Summer* Cedar *Con*Syn	452,67	12,50	1230	150
Summer* Cedar *Con*Wb	420	15	1080	0
Summer*Cedar *Kontrol*Con	615	165	1320	60
Fall* Spruce* Wol-CB*Syn	282,67	7,51	2017,67	372,50
Fall*Spruce* Wol-CB*Wb	272,67	2,52	1887,67	242,50
Fall*Spruce* Wol-CB*Con	272,67	2,52	2057,67	412,50
Fall* Spruce*Tan-E*Syn	265	10	1672,7	27,50
Fall*Spruce*Tan-E*Wb	277,67	2,52	1357,67	287,50
Fall*Spruce*Tan-E*Con	265	10	1557,67	87,50
Fall* Spruce* Con*Syn	342,67	67,50	1610	35
Fall*Spruce* Con*Wb	235	40	1227,67	417,50
Fall*Spruce* Con*Con	262,67	12,50	1417,67	227,50
Fall* Cedar *Wol-CB*Syn	602,67	132,50	3846	1139
Fall*Cedar *Wol-CB*Wb	430	40	3086	379
Fall*Cedar *Wol-CB*Con	430	40	3138,67	431,50
Fall* Cedar *Tan-E*Syn	437,67	32,50	2438,67	268,50
Fall*Cedar *Tan-E*Wb	400	70	2863,67	156,50
Fall*Cedar *Tan-E*Con	437,67	32,50	2591	116
Fall* Cedar *Con*Syn	467,67	2,52	1998,67	708,50
Fall*Cedar *Con*Wb	587,67	117,50	2448,67	258,50
Fall*Cedar *Con*Con	437,67	32,50	1953,67	753,50
Winter*Spruce* Wol-CB*Syn	458	0	1796,67	18,50
Winter*Spruce* Wol-CB*Wb	457,33	0,58	2111,67	333,50
Winter*Spruce* Wol-CB*Con	457,33	0,58	1864	86
Winter*Spruce*Tan-E*Syn	401,33	56,50	1976,67	198,50
Winter*Spruce*Tan-E*Wb	457	1	1541,67	236,50
Winter*Spruce*Tan-E*Con	386,33	71,50	1736,67	41,501
Winter*Spruce* Con*Syn	454	4	1511,67	266,50
Winter*Spruce* Con*Wb	499	41	1811,67	33,50
Winter*Spruce* Con*Con	544	86	1654	124
Winter*Cedar *Wol-CB*Syn	337,67	7,51	2578,33	601,50
Winter*Cedar *Wol-CB*Wb	329	1	2353,33	376,50
Winter*Cedar *Wol-CB*Con	330	0	2511	534
Winter*Cedar *Tan-E*Syn	337,67	7,51	2158,33	181,50
Winter*Cedar *Tan-E*Wb	345	15	1551	426
Winter*Cedar *Tan-E*Con	345	15	2083,33	106,50
Winter*Cedar *Con*Syn	295	35	1438,33	538,50
Winter*Cedar *Con*Wb	262,67	67,50	1611	366
Winter*Cedar *Con*Con	352,67	22,50	1506	471
Spring*Spruce* Wol-CB*Syn	279	9	1348,67	151,50
Spring*Spruce* Wol-CB*Wb	301,67	13,50	1018,67	178,50
Spring *Spruce* Wol-CB*Con	294	6	1393,67	196,50
Spring*Spruce*Tan-E*Syn	324	36	1213,67	16,50

Spring*Spruce*Tan-E*Wb	309	21	1318,67	121,50
Spring *Spruce*Tan-E*Con	234	54	1198,67	1,53
Spring*Spruce* Con*Syn	204	84	1033,67	163,50
Spring*Spruce* Con*Wb	329	41	1093,67	103,50
Spring *Spruce* Con*Con	309	21	1258,67	61,50
Spring*Cedar *Wol-CB*Syn	511	74	1713	87
Spring*Cedar *Wol-CB*Wb	518,33	81,50	1720,67	94,50
Spring *Cedar *Wol-CB*Con	376	61	1953	327
Spring*Cedar *Tan-E*Syn	383,33	53,50	1503	123
Spring*Cedar *Tan-E*Wb	398,33	38,50	1383	243
Spring *Cedar *Tan-E*Con	383,33	53,50	2058	432
Spring*Cedar *Con*Syn	421	16	1583	43
Spring*Cedar *Con*Wb	421	16	1338	288
Spring *Cedar *Con*Con	518,33	81,50	1383	243
Con*Spruce* Wol-CB*Syn	332,67	62,50	2205,33	99,50
Con*Spruce* Wol-CB*Wb	467,67	72,50	2435,33	329,50
Con*Spruce* Wol-CB*Con	340	55	2193	87
Con*Spruce*Tan-E*Syn	397	3,4641	1905,33	200,502
Con*Spruce*Tan-E*Wb	397,67	6,81	2288	182
Con*Spruce*Tan-E*Con	370	25	2038	68
Con*Spruce* Con*Syn	355	40	1960,33	145,50
Con*Spruce* Con*Wb	572,67	177,50	2033	73
Con*Spruce* Con*Con	327,67	67,50	1893	213
Con*Cedar *Wol-CB*Syn	434	44	1987	173
Con*Cedar *Wol-CB*Wb	516,67	38,50	2377	563
Con*Cedar *Wol-CB*Con	351,67	126,50	1802	12
Con*Cedar *Tan-E*Syn	426,67	51,50	1552	262
Con*Cedar *Tan-E*Wb	621,67	143,50	1672	142
Con*Cedar *Tan-E*Con	381,67	96,50	1777	37
Con*Cedar *Con*Syn	478	0	1537	277
Con*Cedar *Con*Wb	456,67	21,50	1597	217
Con*Cedar *Con*Con	636,67	158,50	2027	213

Wol-CB; Wolmanit-CB, Tan-E; Tanalith-E, Syn; Synthetic, Wb; Water-based, Con; Control, TDF; Time of Demolition First, TAB; Time of All Burn

According to wood types, among average first destruction time, the lowest value measured in spruce samples, the highest in cedar samples; complete combustion duration on average is highest in cedar samples, lowest in spruce samples.

According to impregnation substance, average values of first destruction duration is highest in non-impregnated samples, lowest in samples impregnated with Wolmanit-CB, on the other hand, in average complete combustion duration the highest value belongs to samples impregnated with Wolmanit-CB, the lowest belongs to non-impregnated samples.

According to varnish types, first destruction period on average is determined highest in samples applied with water based varnish, lowest in samples applied with synthetic; complete combustion duration on average is highest in samples varnished with water based varnish, lowest in samples applied with synthetic varnish.

According to seasonal change, among average times of first destruction, the highest time measured in summer samples, the lowest measured in spring samples; average durations of complete combustion, highest value is figured out in fall samples, lowest value figured out in spring samples.

Average time for first destruction time effected by seasonal change, varnish type, interaction of impregnation substance and wood type emerges highest in samples impregnated with Tanalith-E and samples applied with synthetic varnish in cedar summer samples, emerges lowest in spruce spring samples applied with synthetic varnish without impregnation. Complete combustion period on average according to seasonal change, varnish type, interaction of impregnation substance and wood type measured highest in cedar fall samples impregnated with wolmanit-CB, synthetic varnished, measured lowest in spruce summer samples applied with non-impregnated synthetic varnish.

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