The Effects of Fire Retardants Paint on Combustion Properties of Fir Wood

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Abstract
The effects of fire retardants paint on combustion properties of fir *(Abies bornmülleriana* M.*)* were examined. For this purpose, fire retardants paint were applied on the surface of test sample according to company's suggestions. The combustion test was performed according to the ASTM-E 69 standard. The mass reduction, release of gasses (CO, NO, O_2), and temperature differences of samples were determined for each 30 seconds during combustion. It was observed that the highest mass reduction occurred in fir wood with fire retardant paint.
Keywords: Fire retardant, Combustion, Varnish, Fir Wood Material

Introduction

Wood has many good properties from the point of view of processing, physical and mechanical properties, aesthetic, environmental and health aspects. Wood continues to play an important role as a structural material in today's high-tech society. In many countries, wood is widely used as a building material: in some areas as the main construction and decoration material (Toker et al., 2012).

As lumber and in reconstituted products, wood is commonly used for house siding, trim, decks, fences, and countless other exterior and interior applications (Cassens et. al., 1991). Wood material has a number of advantages such as good mechanical properties, but shows a low fire resistance (Bednarek and Kaliszuk 2007). Borates have several great advantages as wood preservatives as well as imparting flame retardancy, providing sufficient protection against all forms of wood destroying organisms, have low mammalian toxicity and low volatility, they are moreover colorless and odorless (Hafizoglu et al., 1994; Murphy, 1990; Yalinkilic et al., 1999; Drysdale, 1994; Chen et al., 1997).

Many researchers have studied the effects of combustion properties of wooden materials. Uysal and Kurt studied combustion properties of oriental spruce (*Picea orientalis* L.) impregnated with boron compounds. A borax-boric acid 10% solution was found to be the most successful fire retardant chemical (Uysal and Kurt, 2005). Yapıcı et. al. studied the effects of pretreatment with boric acid, borax and Tanalith-E on combustion properties of varnished oriental beech. It was shown that the highest mass reduction occurred in samples impregnated with boric acid and varnished with polyurethane varnish (Yapıcı et al., 2011).

Baysal et al. have studied the combustion properties of fir wood. They results indicated that the lowest temperature for flame stage, without flame stage, and glowing stage were obtained for specimens treated with boric acid and borax mixture (7:3; weight: weight). The lowest mass loss was found for the specimens treated with a mixture of boric acid and borax (Baysal et al., 2007).

The aim of this study was determinate the effects of fire retardants paint on combustion properties of fir (*Abies bornmülleriana* Mattf) wood.

Material and Method

Material

Fir (*Abies bornmülleriana* M.) was chosen randomly from timber suppliers of Karabuk, Turkey. Blending process was carried out to represent control samples for other groups. A special emphasis was put on the selection of wood material. Accordingly, non-deficient, whole, knotless, normally grown (without zone line, reaction wood, decay, insect or fungal infection) wood materials were selected.

Experimental Study

The oversized test samples were dried until they were stable at 20 ± 2 °C and 65 ± 3 % relative humidity in climate room. Later on they were cut with the dimensions of

9x19x1016 mm according to the ASTM E–69-02 (1975) and were finished with fire retardant paint. 15 samples were manufactured for each test sample. Totally, 30 test samples were prepared.

Method

Execution Test

The combustion test was carried out according to the ASTM E–69-02 (1975) but some changes were made in the stand. For this purpose, a digital balance having 0.01 g sensitiveness has been used for determination of mass reduction of materials when they are burnt. Butane gas was used to make an ignition flame. The gas flow is standard as the high of flame is 25 cm and the temperature must be 1,000 ^{o}C.

The distance between the bottoms of the test samples, which were hanged inside of the fire tube and the top of the gas pipe must be adjusted to 2.54 cm. During the test, mass reduction, temperature and released gas (CO, NO, O_2) were determined in every 30 seconds. The test was made under a chimney where the flow of air blown was drawn with natural draft. At the beginning of combustion test flame source was used for 4 minutes then flame source was taken away and it was continued for 6 minutes. The test has lasted for 10 minutes.

Testo 350 M and XL flue gas analyzers were used for measuring the concentration of the released gasses (CO, NO, O_2), and temperature variation. The probe was inserted into the first hole from the top of the fire tube.

Result and Discussion

The average air-dry density of Fir samples is 0.41 g/cm^3.

Fir wood samples were applied fire retardants paint and then combustion properties were determined. As a result of combustion experiments, the average mass loss, temperature, O_2, CO values are shown in Table 1.

Table 1. The average values of combustion test

	Mass Loss Value (%)		Temperature Value °C		O_2 Value %		CO Value ppm		NO Value ppm		Flue Temp. Value °C	
Time	Control	Fire Retd.	Control	Fire Retd.	Control	Fire Retd.	Control	Fire Retd.	Control	Fire Retd.	Control	Fire Retd.
1	2.98	3.13	87.9	84.1	20.02	20.25	36.7	69.1	0.4	32.7	80,6	73.9
2	6.45	4.7	116.1	113.6	19.41	19.98	70	127	1.3	38.9	105.8	84.3
3	10.79	6.9	150.1	127.3	19.1	19.82	92.1	150.9	1.9	36.4	118.5	89.4
4	16.9	8.9	176.2	147.8	18.83	19.59	107.5	161	3.2	29.1	132.5	92.3
5	25.9	11.31	204.6	163.2	18.58	19.38	148	179.3	3.9	26.3	142.4	98.8
6	35.43	13.88	228.3	175.8	18.65	19.06	264.3	198.6	3.3	25.5	140.6	105.7
7	44.9	18.08	248	185.8	18.57	18.87	414.8	230	3.5	24.9	142.5	112.2
8	51.27	19.59	269.8	195.2	18.36	18.65	484.9	219.3	4.3	21.1	149.3	111.9
9	59.16	21.25	310.9	195.8	17.91	18.84	487.3	242.6	4.9	14.3	155.4	84
10	65.74	22.02	384.9	185.5	18.13	19.11	437.5	215.3	6	8.3	153	64.6
11	76.35	22.41	425.7	171.3	18.2	19.57	309.5	142.7	6.5	6.3	149.2	56.2
12	84	22.8	424.6	158.9	18.47	20	317.9	73.7	6.5	4.1	130.2	47.6
13	88.13	23.24	405.6	148.3	18.94	20.42	282.7	39.9	5.7	3	114.7	44.5
14	91.03	24.37	359.4	139.9	19.54	20.74	204.7	18.9	4	2.3	104.2	42.3
15	94.01	25.04	309.5	131.7	19.71	20.95	254.1	13.2	3.3	2.1	96.7	40.9
16	95.72	25.71	271.3	124.4	20	21	233.1	7.7	2.7	2	89	40.3
17	96.78	26.67	238.3	118.8	20.33	21	183.3	5.9	1.5	1.6	81.6	39.1
18	97.56	27.3	218.4	113.3	20.57	21	116.4	4.1	0.5	1.6	76.8	38.2
19	97.82	27.78	201.1	108.3	20.69	21	70.2	2.2	0.3	1.6	73.4	37.7
20	98.37*	28.09	185.5	103.4	20.72	21*	58.3	1.3	0	1.4	67.1	37.1

**Highest value*

According to test result (Table 1), the highest mass loss value (98.37 %) was obtained in control fir wood samples; the lowest mass loss value was determined in case of finishing process by applying fire retardant paint on fir wooden material (28.09 %). The fire retardant paint has increased the combustion resistance.

As a result of combustion test the highest reduction (21 %) of O_2 concentration was

measured in fir wood sample with paint. The lowest value of O_2 concentration was determined in case of control fir wood samples (17.91 %). The fire retardant paint has decreased the combustion, so that O_2 values of control fir wood samples were measured as the lowest.

According to Table 1, the highest temperature value (425.7°C) was observed in control fir sample. The lowest value (84.1°C) was found in fir wood samples with applied fire retardant paint. This is because the fire retardant paint had reduced the combustion temperature.

The highest value of CO concentration (487.3 ppm) was observed in fir wood sample; the lowest value of CO concentration was determined in fir wood with applied fire retardant paint (1.3 ppm).

As a result of combustion test the highest value of NO concentration was found in fir wood with applied fire retardant paint (38.9 ppm). The lowest value of NO concentration was obtained in fir wood sample (0 to 0.4 ppm).

Consequently, samples with applied fire retardant paint has 60% less combustion properties than control group samples. In former studies they had almost the same experimental values (Uysal and Kurt 2010; Uysal et al., 2011).

After combustion of fir wood samples with applied fire retardant paint, the temperature values decreased in chimney. The effect of fire retardant paint on CO value, until the complete combustion, had 40% less than control group samples. Fire retardant paint significantly increased NO values. This might suggest the use of fire retardant paint on furniture which could be exposed to combustion.

References

ASTM-E 69. 1975. Standard Test Methods for Combustible Properties of Treated Wood by the Fire Apparatus.

Baysal E., Altinok M., Çolak M., Ozaki K.S., Toker H., 2007. "Fire resistance of Douglas fir (*Pseudotsuga menziesi*) treated with borates and natural extractives" Bioresources Technology 98 1101-1105

Bednarek, Z., Kaliszuk-W, A., 2007. "Analysis Of The Fıre- Rotectıon Impregnatıon Influence On Wood Strength" Jour. of Civil Eng. and Manag., vol,13, No; 2, 79-85.

Cassens, Daniel L.; Feist, William C. 1991. "Exterior Wood in the South: Selection" Appl., and Fin. Gen. Tech. Rep. FPL-GTR-69. Madison, Wl: U.S. Dep. of Agr., Forest Serv., Forest Prod. Lab. 60 p.

Chen, P.Y.S., Puttmann, M.E., Williams, L.H., Stoke, D.D., 1997. Treatment of hardwood lumber with borate preservation. Forest Products Journal 47, 63–68.

Drysdale, J.A., 1994. Boron treatments for the preservation of wood. A review of efficacy data for fungi and termites. The International Research Group on Wood Preservation. Document IRG/WP, 8 p.

Hafizoglu, H., Yalinkilic, M.K., Yildiz, U.C., Baysal, E., Peker, H.,Demirci, Z., 1994. Utilization of Turkey's boron reserves in wood preservation industry. Project of Turkish Science and Tech. Council (TUBITAK), Code: TOAG-875, 377 p.

Murphy, R.J., 1990. Historical perspective in Europa. In: Margeret Hamel (Ed.), Proceedings of the First International Conference on Wood Protection with Diffusible Preservatives. 28–30 November, Nashville, Tennessee, pp. 9–13.

Toker H., Baysal E., Ozcifci A., Altun S., Esen R., 2012. "Combustion Properties Of Laminated Veneer Lumbers Impregnated With Some Chemicals" 12th International Combustion Symposium Kocaeli/Turkey

Uysal, B., Kurt, Ş. 2005. "Borlu bileşiklerle emprenye edilmiş ladin ağacının yanma özllikleri" Ladin Sempozyumu Bildiri kitabı 2, 845.Trabzon.

Yapıcı, F., Uysal, B., Kurt, Ş., Esen, R., Özcan, C. 2011. "Impacts of impregnation chemicals on finishing process and combustion properties of oriental beech (*Fagus orientalis* L.) wood", BioResources, 6(4):3933-3943.

Yalinkilic, M.K., Takahashi, M., Imamura, Y., Gezer, E.D., Demirci, Z., Ilhan, R., 1999. Boron addition to non or low formaldehyde crosslinking reagents to enhance biological resistance and dimensional stability for wood. Holz als Roh-und Werkstoff 57, 351–357.