VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

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COMBUSTIBLE PARAMETERS OF NATIVE TIMBER MODIFICATED BY BLOKK WOOD METHOD

Abstract

Wood is one of the most ancient building material. It is available anywhere, it is easy to shape, it is flexible and strong enough to make it an excellent building material. The use of wood also has a disadvantage, which is the flammability. There are countless literatures and procedures in the topic of the flame retardancy. The modification involves the use of wood preservatives. The authors present the so-called BlokkWood method used in Hungary as a new procedure and its effect, supplemented with their own tests. The wood were subjected to several types of testing. These are partly standard and partly non-building material standard, but in case of fire, the effect must be taken into account. The specimens were mainly Hungarian wood species. The purpose of the paper is to investigate whether the BlokkWood method is suitable for the efficient modification of trees.

Keywords: flame retardant of wood, fire tests, modification of wood, BlockWood method

BLOKK WOOD ELJÁRÁSSAL MODIFIKÁLT HAZAI FAANYAGOK ÉGHETŐSÉGI PARAMÉTEREI

Absztrakt

Az ember számára a faanyag az egyik legősibb építőanyag. Beszerzése egyszerű, könnyen alakítható, megmunkálható, rugalmas és szilárdsága is megfelelő ahhoz, hogy kitűnő építőanyag lehessen belőle. A faanyagok növekvő használata mellett mindig ott volt a komoly probléma is: hogyan lehet az éghetőséget csökkenteni. Óriási kutatási háttere és szakirodalma van a fák égéskésleltetésének, számtalan eljárás létezik. A modifikálás maga faanyagvédelmi szerek alkalmazását jelent. A szerzők a cikkben egy Magyarországon új eljárásként alkalmazott az ún. BlokkWood módszert és hatását mutatják be, kiegészítve saját vizsgákatokkal. Többféle vizsgálatnak vetették alá a kezelt fákat. Ezek részben szabványos, részben nem építőanyag szabványos, de tűz esetén mindenképpen számolni kell a hatásával. Igen nagyszámú minták a hazai fafajok közül kerültek ki. A cikk célja megvizsgálni, hogy a BlokkWood módszer alkalmas-e a fák a hatékony modifikálására.

Kulcsszavak: fa égéskésleltetés, tűzvédelmi vizsgálatok, fák modifikálása, BlockWood módszer

1. INTRODUCTION

Wood is one of the most ancient building material. Wood is available anywhere, it is easy to shape, it is flexible and strong enough to make it an excellent building material [1] [2] [3]. In addition to the increasing use of the wood, there has always been a serious problem with it: how to reduce its flammability? We can find many literatures in connection with the flame retardant of wood and case studies of the firefighting [4] [5] [6] [7]. Modification is a process that changes the composition of the wood in order to give new properties for it [8]. It can extend the application area and ensure the production of new products. We would like to present the so-called BlokkWood method used in Hungary as a new procedure and its effect, supplemented with our own tests. The treated woods were examined in several forms such as partly standard (fire propagation, mass loss) and partly non-building material standard (radiant heat effect), but in case of fire its effect must be taken into account.

2. PROPERTIES AND COMBUSTION OF WOOD

Wood can also be called three-phase solid structures.

The main components of the cell wall of the wood structure are the followings:

- 50% carbon

- 6% is hydrogen
- 43% is oxygen
- 1% is other materials

N, P, S - metallic elements: B, Mn, Cu All wood are 99% same in composition. More than 100 tree species are known on Earth, and this is due to the remaining 1%. The most characteristic feature of wood is that their flammability does not depend on their chemical composition, but primarily on their porosity. The porosity of wood depends on the type of wood, the density of wood (ζ=m/V) 800-400 kg/m^3 and the environmental conditions (arable land, climate, open space). Regarding the density of the wood, it can be said that its value without a solid cell cavity is the same in case of all trees (1.56), only their structure differs from each other [9].

Distribution of tree species in Hungary:

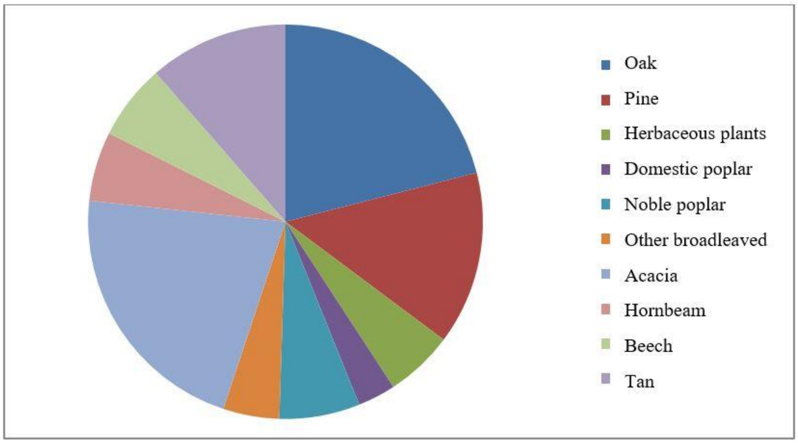

Figure 1 - Distribution of tree species in Hungary. Created by the Authors.

The combustion of wood

The flammability of wood is well known. Taking into account the properties of the wood material and its properties determined by its tissue structure, its fire resistance can be planned and controlled. In terms of flammability, architects are working together with professionals to reduce the flammability of wood. The fire behaviour of wood is not as unfavourable as many people think. Both theory and practice show that metal structures lose their load-bearing capacity and stability quicker than the wood structures. Acacia has the most favourable burning properties. It has the highest energy heat radiant and the highest glow resistance. The rate of flame propagation in the direction of the fibre cannot be evaluated, and the value perpendicular to the fibre is the lowest. In contrast, poplar has the worst properties [10].

3. MODIFICATION PROCEDURES

The main wood modification procedures and their mechanisms [11]: The modification can basically be divided into two major groups:

- *Active processes*: the process of changing the chemical structure of a substance (chemical modification).
- *Passive processes*: during the process, the properties of the material change, but the chemical structure remains unchanged (physical modification) [9].

Grouping of modifications according to their mechanism of action:

- Filling cell cavities
- Filling the cell wall
- Reaction of OH groups
- Coupling of OH groups
- Change the cell wall structure [12] [13].

Chemical modification

It is a process where the components of a chemical reagent and a wood polymer react with each other, thereby forming a covalent bond. The purpose is to reduce the OH groups during the modification. Its role in the modification is: Most modification processes affect these in some form. Their amount affects the water adsorption and the dimensional stability of the wood.

Main chemical modification processes:

- Esterification reactions of wood (acetylation with acetic anhydride, ketene, acid chloride)
- Furfurylation (with furfuryl alcohol, complex reactions)

- treatment N-methylol-DMDHEU (Dimethylol dihydroxyethylene urea) reacts with the OH groups of lignin and hemicellulose and is able to convert itself into a complex polymer
- Reactive oil treatment (with linseed oil) at increased temperature
- Impregnation of the cell wall [9] [12].

The main characteristics of thermal modification

Thermal modification is still used with the so-called BlockWood technology in Hungary. The company combines continuous temperature change and a special catalyst during the processing of wood. Another feature of the product is that the wood can no longer to absorb the moisture, so it is also suitable for buildings with more durable structures. During the process, the macromolecular system undergoes chemical changes due to heat transfer. This modifies the following physical and biological characteristics of the wood. We can find significant differences between the individual tree species. For example, green trees are characterized by intense weight loss during the modification process [12] [13] [14].

Test specimens

Treated and untreated test specimens were provided by the BlokkWood company (Figure 1, Table 1).

Table 1 – Type of specimens and their markings

Specimen	**Marking**
Ash 1.	K1
Ash 2.	K2
Treated ash 1.	KK1
Treated ash 2.	KK2
Long treated ash 1.	KK3

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Long treated ash 2.	KK4
Poplar 1.	NY1
Poplar 2.	NY2
Treated poplar 1.	NYIK1
Treated poplar 2.	NYIK2
Birch 1.	NYÁ1
Birch 2.	NYÁ2
Treated birch 1.	NYÁK1
Treated birch 2.	NYÁK2
Pine 1.	F0
Pine 2.	F1
Treated pine 1.	FK1
Treated pine 2.	FK2

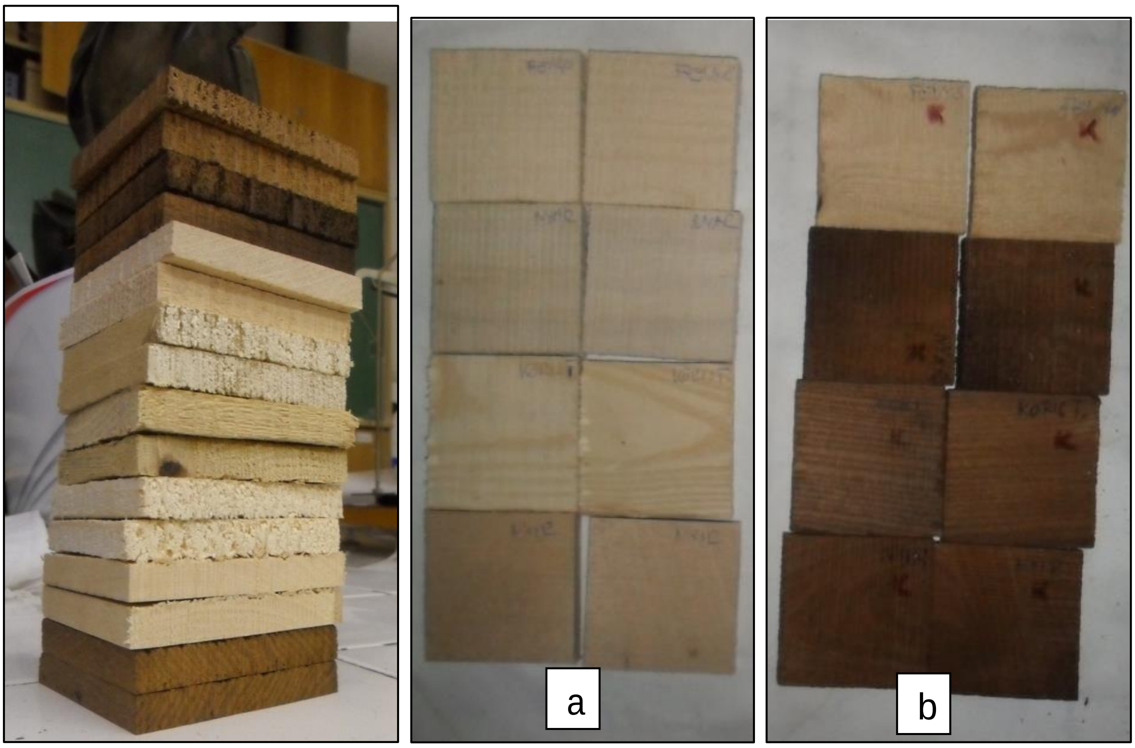

Figure 1 - Test specimens **a)** untreated, **b)** treated (modified). Created by the Authors.

4. TEST METHODS

We selected four types of the combustion tests. The test method follows the change that a wood specimen undergoes during combustion. We made the tests in the Fire Protection Laboratory of the University of Óbuda.

1. Testing of wood and wood substituting materials treated with flame retarding substances. Method of Lindner (According to MSZ 9607/1-83).

The device illustrated in Figure 2 shall be used to verify the effectiveness of the flame retardant treatment. The size of the specimens is: 10cm*10cm*1 cm. The surface of the specimen is ignited until all of the hexamethylene tetramine is burned. The combustion material must be ignited and the specimen should place quickly on the combustion opening (Figure 2). It is important that the specimen covers the entire combustion opening (Figure 3).

Figure 2

Figure 3

Figure 4

Burning of wood specimens in a Lindner device. Created by the authors.

Classification of the material: the preservative treatment is appropriate if the weight loss of the specimen in case of protected wood does not exceed 2.5 g.

2. Horizontal flame propagation speed test according to DIN 75200 and ISO 3795 standard.

The test was performed in an ATLAS DHW (Horizontal Flame Chamber) (Figure 5).

The size of the specimens was: 33cm*10cm*1 cm.

Classification of samples: We should observe whether the flame reaches 38 mm length in 30 seconds and extends up to 254 mm.

We give the rate of the flame propagation (mm/min).

Materials which do not reach the 38 mm flame length in 30 seconds, we assumed their flame spread rate as 0.


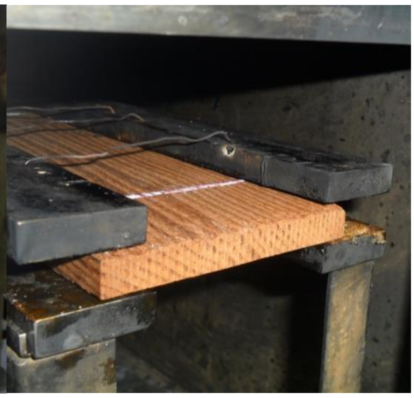

Figure 5 Figure 6 Figure 7

Burning of wood specimens in horizontal arrangement. Created by the authors.

3. The third test is the vertical flame propagation rate according to DIN 4102 and ISO 11925-2 standard.

Test procedure: The test specimen is placed in a metal support structure. The size of the specimens is: 33cm*10cm*1 cm. The limit at 150 mm should be marked on the specimen. This limit is the criterion for flame propagation within 20 and 60 seconds.

We place the PG flame 40 mm high at a distance of 1 cm from the mounted specimen. After that we heat the specimen for 20 seconds (Figure 8). After 20 seconds we stop the gas flame and with a stopwatch we measured when the resulting flame goes out (Figure 8-9). We recorded all these values in a protocol.

Evaluation of the test: From the measurement of the combustion length and the time, the vertical flame spread rate of each material can be calculated [mm/min]. It is generally stated that materials do not reach the 150 mm limit in 20 seconds. So, in our opinion, the modification of a wood cannot be qualified by specifying the vertical flame spread rate.

Figure 8 Figure 9 Figure 10

Burning of wood specimens in vertical arrangement. Created by the Authors.

4. The fourth test was to measure the ignition time with radiant heat according to the ISO 9239-1 standard

The name of equipment we used in the test: KALVK 1.

The temperature of radiant iron core: 700 °C, released heat flux: 2±0,2 W/cm^2 at a distance of 3 cm from the heating core (Figure 11). The size of the specimens during the examination: 7cm*7cm*1cm

Test procedure: The specimen should be placed under the heat-emitting core and then measured with a stopwatch to see when it begins to smoke, glow, or flame, and when it burns across the entire cross-section (Figure 11-16). We recorded these values in the protocol.

Figure 11 - KALVK 1, radiating iron core. Created by the Authors.

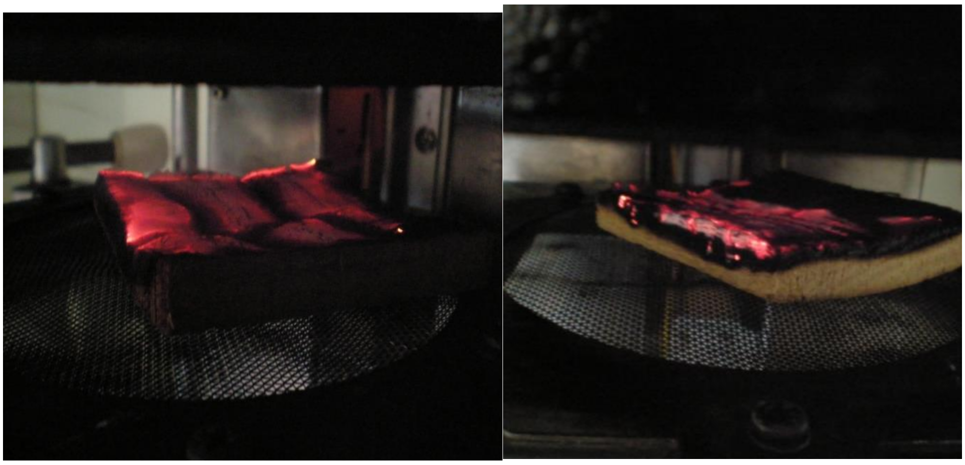

Figure 12 - Deformation of specimens under heat load. Created by the Authors.

5. FIRE INVERSTIGATION RESULTS

During our investigations we obtained the following results in relation to the modified wood materials:

In case of the weight loss test, none of the wood types (both treated and untreated) correspond (Figure 14). It should be emphasized that during the test the poplars also burned over the entire cross-section (1cm).

It can also be observed that the treated ash for a short time has the greatest weight loss. However, this value is not much lower for other treated and untreated ash or birch. Treated poplars have the lowest value among both treated and untreated wood.

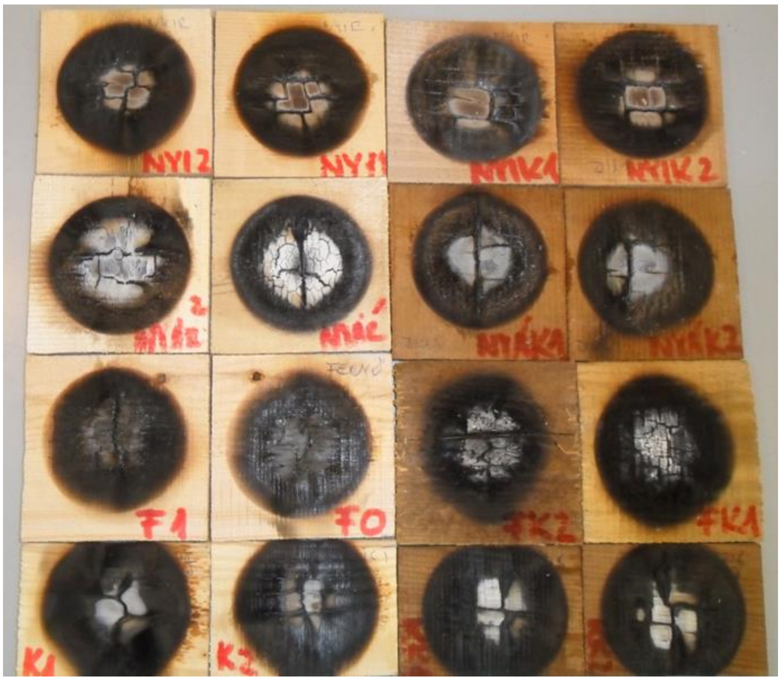

Figure 13 – Specimens used in the Lindner test. Created by the Authors.

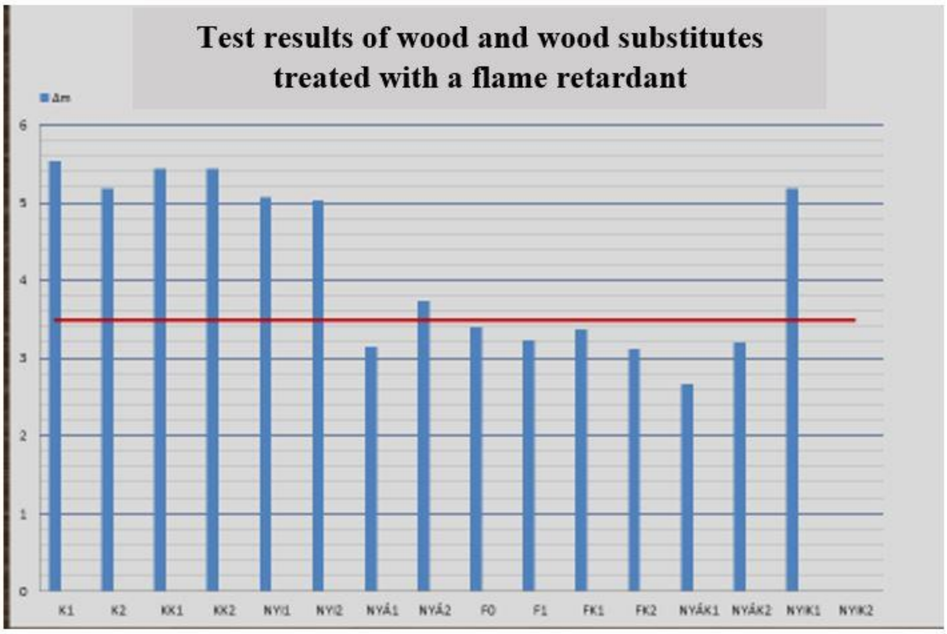

Figure 14 - Mass losses during the Lindner test. Created by the Authors.

All woods reached a low value in terms of *horizontal flame propagation speed*. During the test time (30 sec), none of the specimens showed a significant propagation speed. The best values are obtained in case of long treated ash, which has practically zero flame propagation speed. Of the untreated wood, birch and ash have the lowest values. In contrast, treated and untreated poplar showed the worst (highest) values.

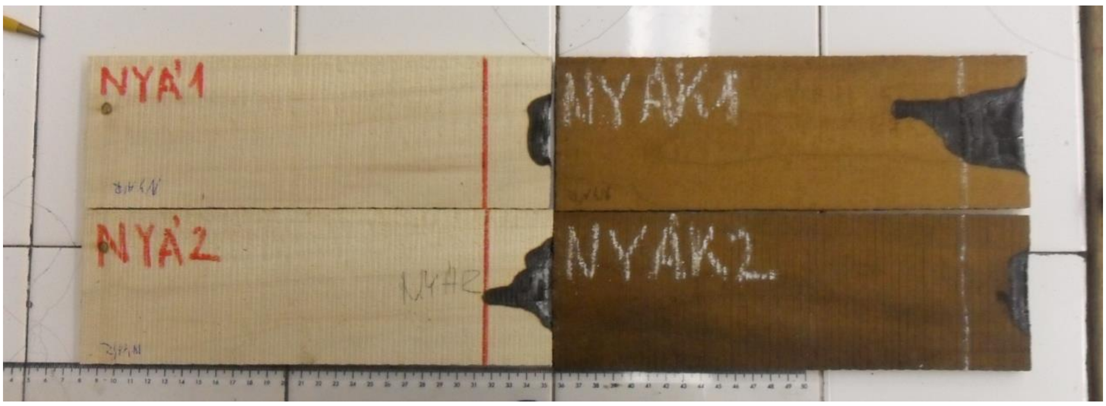

Figure 15 - treated and untreated poplar showed the longest burning result. Created by the Authors.

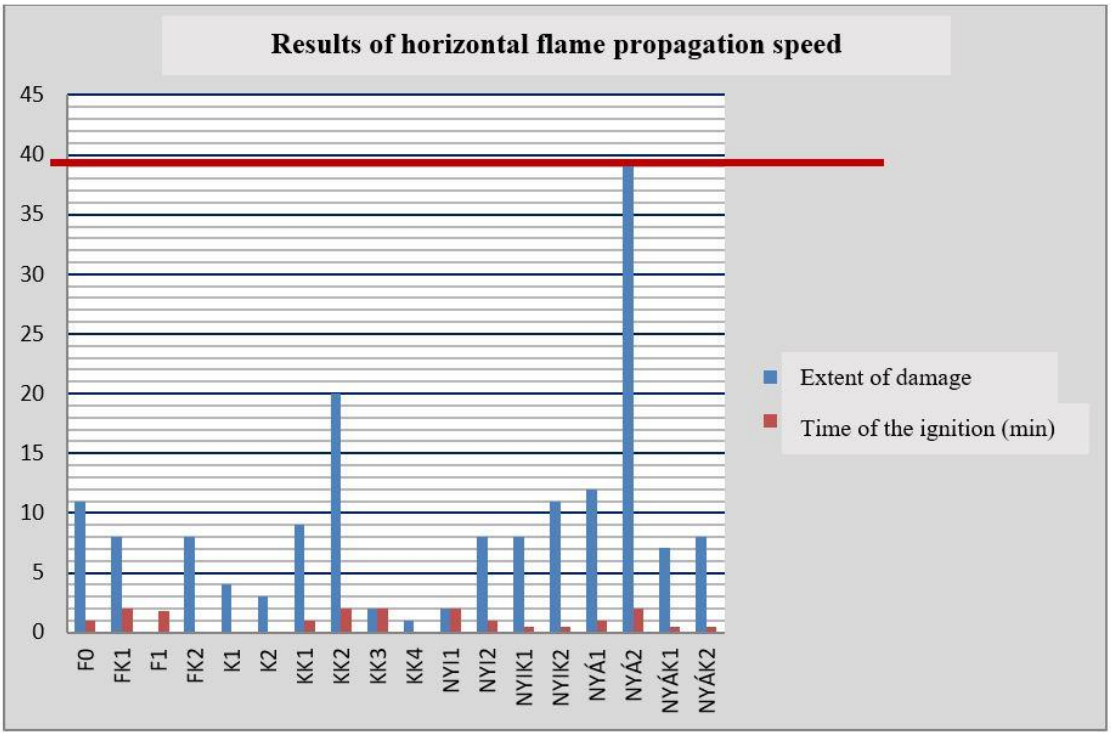

Figure 16 – Horizontal burn of the specimens. Created by the Authors.

In case of the *vertical flame propagation rate*, the untreated and long-treated ash and the untreated and treated pine showed the best results. According to the standard, they did not ignite in 20 seconds, so their vertical flame propagation is practically 0. The reason for this is that the ignition temperature has not been reached in the given time. Poplar and birch showed worse results. The highest value was shown by untreated poplar, which reached the 150 mm limit in 54 seconds.

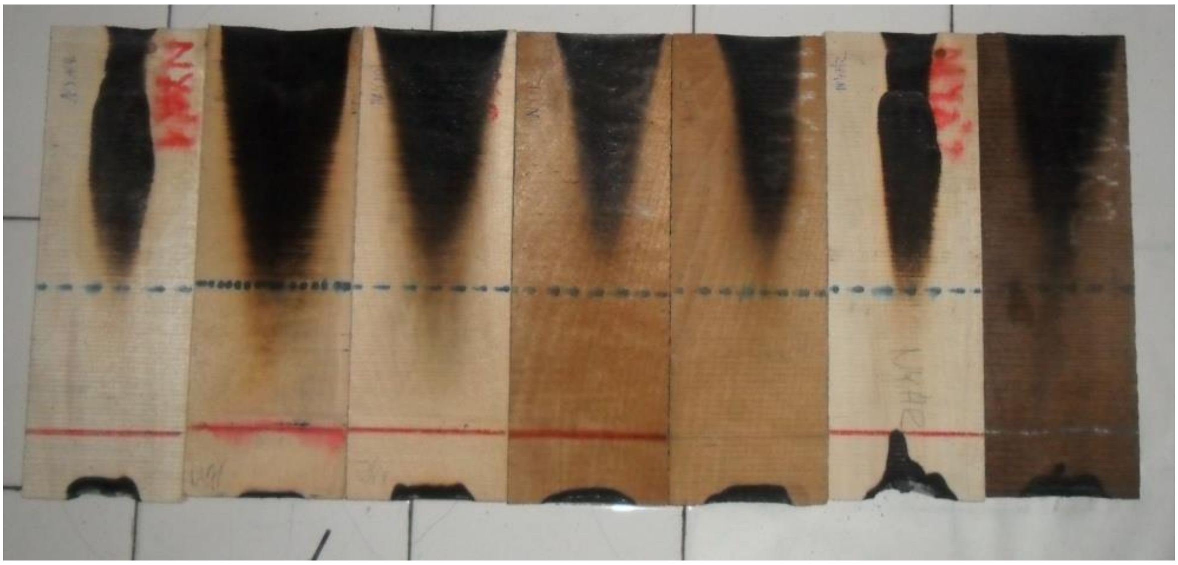

Figure 17 - Some specimens of the vertical flame propagation rate after the test. the Authors.

Combustion of the ignition time with radiant heat resulted in two types. In the first case, the distance between the specimen and the radiating iron core was 3 cm and the heat flux was 2 ± 0.2. Because of these parameters, no specimens ignited but they were burned by solid phase combustion. Ash showed the best results and the poplar showed the worst. In the second case, the distance between the specimen and the radiating iron core was 1.3 cm and the heat flux was 2.6 ± 0.2. In case of this setting, most of the specimens exploded, with an exception of the untreated ash, which burned with solid-phase combustion. The last time the ash specimens ignited, while the untreated and treated poplar was the earliest.

Figure 18 – (2 W/cm^2) All of the specimens after ignition. Created by the Authors.

6. SUMMARY

Euroclass certifications are not sufficient for the use of wood for construction purposes. There are different combustion conditions behind the tests. As a result, a different rating is given to the same wood. The effect of modification procedures and the flame retardant effect is not equally prevailing during the various combustion tests. Based on our few results, we can determine that the modified wood (typically untreated wood) can be classified into class C and Cn. This is because both vertical and horizontal flame propagation rates are negligible. However, weight loss and smoke generation justify classification in the worse category. The accuracy of the classification is also confirmed by the results of the flash point test we made on a few pieces. Studies like this can also support other researches in the topic [15].

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