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Fire properties of exotic wood species covered with protective oils on the basis of the oxygen ratio.

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Abstract: *Fire properties of exotic wood species covered with protective oils on the basis of the oxygen ratio.* Increasing use in many sectors of the market, natural materials, synthetic and organic increases the risk of fire. Knowledge of methods by which it is possible to know the fire characteristics of materials plays a big role. The aim of this work was to determine the oxygen index for exotic species of wood, covered with decorative protective preparations based on natural oils. After service oil samples oxygen index value decreases regardless of the used wood species and type of oil. Covering wood with oil preparations adversely affect fire characteristics of material.
Keywords: oxygen ratio, oxygen index, flammability, exotic wood,

INTRODUCTION

The volume of called as oxygen ratio or oxygen index introduced Fenimore and Martin (1966) and specify a measure of the flammability of materials, that is, the ability to keep burning after the flame. The numerical value of the oxygen index (OI) shall be determined using the following formula:

$$OI = \frac{[O_2]}{[\sum N_i]} * 100\ \%$$ - for multicomponent gas mixtures

$$OI = \frac{[O_2]}{[O_2]+[N_2]} * 100\ \%$$ - for two component gas mixtures

where:

- $[O_2]$ i $[N_2]$ – concentration of oxygen and nitrogen in the two component mixture
- $[N_i]$ – the concentration of the i-th component in the gas mixture in a multicomponent gas mixtures

The oxygen index is typical size for organic material, and means the concentration of oxygen in the mixture of gases (oxygen and nitrogen) or multicomponent gas mixtures, which is needed for combustion of the material after it ignition. This indicator is very useful to describe for various types of polymers, plastics, wood or wood composites (WPC). Method of measuring the OI has been standardized at national (PN-76 C-89020) and international level (ISO 4589) (Janowska et al. 2007, Stark et al. 2010, White, 1979). For the oxygen indicator it's taken such a concentration of oxygen in the mixture of oxygen and nitrogen, which in the test sample is kept uniform burning flame. The oxygen index is essential, when comparing for polymeric materials. Janowska et al. (2007) considers that the materials for which OI ratio is less than or equal to 21% are flammable, while those for which OI is greater than 21% are fire-proof. In turn, Gilman (1999) feels for fire-proof materials, those that have OI between 21-28%, and those for which the indicator is equal to, or greater than 28 are non-combustible. Table 1 shows examples of values for oxygen ratio of wood, polymeric materials and composites WPC. The aim of this work was to compare the oxygen index of natural and protected with oils exotic wood species.

Material	Oxygen Index [%]
Poliethylene	17 – 19
Polipropylene	17 - 20
PVC	40 - 46
Poliamide	23 - 29
cardboard	23
Carbon fibre	60
Pine wood	22 – 25
Beech wood	22 - 24
Oak wood	24,6
Poplar wood	22,5
hardboard	22,1
chipboard	24,5
plywood	19,7

Table 1. Examples of values according to oxygen ratio (Janowska et al. 2007, White 1979, Stark et al. 2010)

MATERIALS AND METHODS

The research was conducted based on the Polish standard PN-76-C-89020 on the three exotic wood species: Tallow tree (*Detarium senegalense* Gmel.), light red meranti (*Shorea* sp.), teak (*Tectona grandis* Linn f). Test method determine the minimum oxygen concentration in the mixture of oxygen and nitrogen, by which the sample intended to test burns. Samples from each species of wood with dimensions: 100 mm x 10 mm x 5 mm have been equally covered with 3 commercial oil preparations for wood: A, B, and C. Application to oil dip method at least 75 mm in length of the sample. Two layers of oil were applied. Igniting the sample lasted 10 seconds in order to avoid a larger combustion samples from an external source. If the sample is burned completely, the flame front crossed the line75 mm or sample burned 180 seconds from disconnect an external source it had to change the test sample and the next measurement performed with a lower concentration of oxygen in the mixture. However, if the flame on a sample faded out in less than 180 seconds, sample had to be changed and the next measurement performed with a higher concentration of oxygen in the mixture. Perform these operations until the method of successive approximations a limit the percentage of oxygen, at which a sample burns up completely, and after reduction of the oxygen content in the mixture about 2-3% of the sample goes off. After finding this boundary, the measurement must be performed several times on oxygen concentration limits, in order to confirm the result.

RESULTS AND DISCUSSION

The highest value of the oxygen index for Tallow tree wood have shown control (K)samples: for burnt 25.47%, and the unburnt 25.00%. For samples coated with oil A the value of this indicator was lower and amounted respectively 24.53 and 24.05%. Indicator values for the other two oils are the same and are as follows: 23.08% for burned and 22.58% for unburnt (Figure 1). The shortest burning time reported for samples coated with oil A (150 s), and also the biggest burnt section, which on average was 73.5 mm for K samples recorded burning time amounted to 160 s, a couple burned section to 68 mm samples covered with oil C showed the burning time 177 s, and the size of the burn is 61 mm. Samples secured by oil B were on fire and had burned section respectively 180 s and 57 mm. In the case of samples that have not been burnt, the shortest burning time reported K - 32 s, for samples with oils A and B – 34 s, and the longest time was obtained for samples with oil C - 69 s. The shortest burned section was for samples K and with oil B - 4 mm, with oil A the length of this amounted to less than 6 mm, and the C oil more than 10 mm.

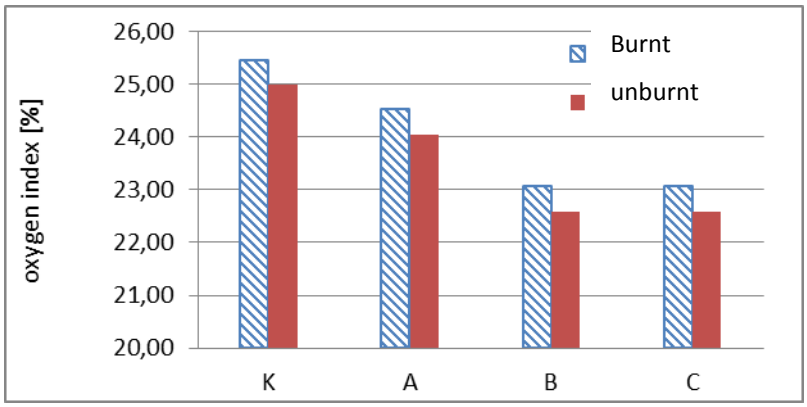

Fig. 1. The oxygen index value for tallow tree wood with oils

Figure 2 shows the values of oxygen indicator for Meranti wood. The highest amount of oxygen in the mixture, needed K samples, where oxygen index was: for burnt 27.71%, and the unburnt 27.27%. In the case of samples covered with oils values were smaller: for oil B suitably 25.47% 25.00, for A 25.00% and 24.53%, for C 23.08% and 22.58%. For K, A and B burned samples, time of burning without source of fire ranged within 150 s, while the length of the burnt section was, on average 75 mm. Samples with oil C fired 30 s longer (180 s), and the distance was 57 mm. For samples that have not been burnt, the longest time holding the fire were for the samples with oil C - ca. 43 s. Shorter time set for samples with oil B (36 s), in the case of samples with oil A and K time was similar - 28 s. With regard to the length of burnt section for samples with oil C was 4 mm, for samples with oils A and B the length of this was 5 mm, and for K samples much more than 6 mm.

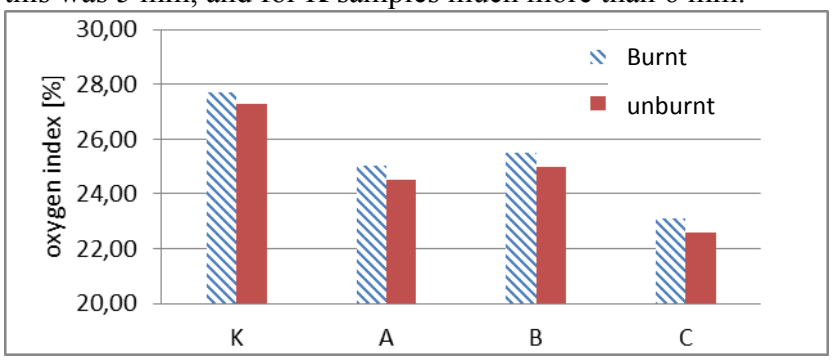

Fig. 2. The oxygen index value for Meranti wood with oils

The figure. 3 shows the oxygen index value for Teak wood. The highest value reported for K samples: for burnt 25.93% and 25.47% for unburnt. For samples with oils A and B oxygen index values were identical and were respectively 23.57 and 23.08%. The smallest value reported for samples with oil C: 23.08% for burned and 22.58% for unburnt. The shortest burning time without source of fire (about 163 s) and at the same time the largest burned distance 75 mm was observed for K samples. Samples with oil B have a longer burning time - 175 s, and burning section was 69 mm. For wood covered with oils A and C the time of burning was 180 s while the burned sections were different and were as follows: 61 and 65 mm respectively for oil A and C.

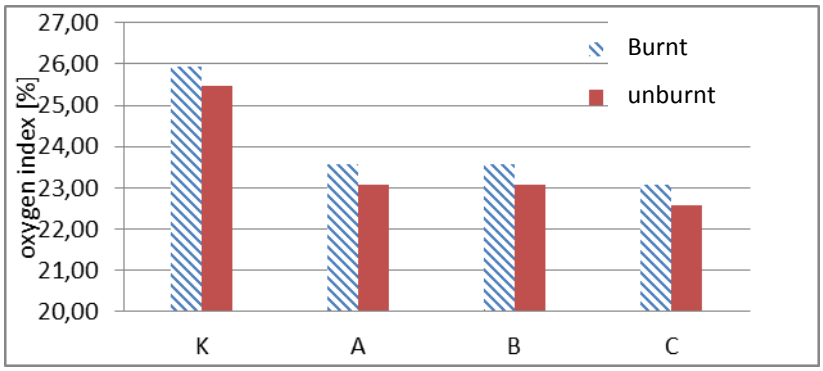

Fig. 3. The oxygen index value for Teak wood with oils

CONCLUSIONS

- After protection of samples with oil preparation the oxygen ratio decreases regardless of the species and the type of oil,
- The largest decline in oxygen ratio in relation to the control samples were observed in the samples covered with oil C. The smallest decrease in oxygen ratio compared to the control samples showed the wood covered with oil A, with the exception of Meranti wood,
- Oxygen indicator for all species of wood, regardless of the selected oil, is located within the limits of the hard flammable material 21-28%. Regardless of the wood species for control samples contain oxygen indicator values in the same range.

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Streszczenie: *Cechy palnościowe drewna gatunków egzotycznych pokrytego olejami ochronno-dekoracyjnymi na podstawie wskaźnika tlenowego.* Zwiększenie stosowania, w wielu branżach rynku, materiałów naturalnych, syntetycznych i organicznych zwiększa ryzyko pożaru. Znajomość metod, dzięki którym jest możliwe poznanie cech palnościowych materiałów odgrywa dużą rolę. Celem tej pracy było określenie indeksu tlenowego dla egzotycznych gatunków drewna, pokrytych ochronno- dekoracyjnymi preparatami na bazie olejów naturalnych. Po pokryciu próbek olejami wartość wskaźnika tlenowego maleje bez względu na używane gatunki drewna i rodzaj oleju. Pokrywające drewno preparaty olejowe niekorzystnie wpływają na cechy palnościowe materiału.

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