Method of increasing the fire resistance of wood

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Abstract. The use of impregnation based on soda ash and boric acid as one of the ways to increase the fire resistance of wood is considered. The method of testing the initial impregnation on three types of wood is described. The result of the tests was a justification for the use of this impregnation to increase the fire resistance of wood.

1. Introduction
Fire resistance of wood is achieved with the help of flame retardants and antiseptics[1-3]. The action of the former is to protect the material from direct contact with fire or by limiting the oxygen supply to it, thus preventing it from catching fire. The latter make the wood more resistant to the effects of various types of microorganisms and insects.

2. A review of the literature
Ensuring fire safety of buildings and structures containing materials made of wood is achieved by processing with various flame retardants. [4,5,6]. For these purposes, the most often used aqueous solutions of borax, potash, ammonium phosphate, sodium acetate etc.
Currently, scientists continue to search for flame retardants and antiseptics, relatively cheap and environmentally friendly. In connection with the provision of fire protection, the problem of wood remains relevant. [7,8]. For it is necessary how to determine the substances (or), their depth and distribution by [9].

3. Materials and methods
To increase the fire resistance of wood, it is proposed to use an impregnation from a mixture of soda ash and boric acid on a water basis, consisting of a liter of water, 0.11 kg of a mixture of soda ash and boric acid in a ratio of 3:1.
For the production of soda ash, “food” soda (sodium bicarbonate NaHCO 3) is used and calcined at a temperature of 200°C until the release of water vapor and carbon dioxide CO 2 is stopped. Soda ash is used as a flame retardant, limiting oxygen access to the wood as much as possible, and eliminating the occurrence of fire in a wooden structure. Boric acid is an antiseptic and makes wood biostable.
For conducting the experiment, prepared samples from birch, beech and pine. 40*40*40 mm, are subjected to impregnation with the prepared mixture according to the following scheme:

- to form the 1st layer of impregnation, the samples are placed in the solution for 40 minutes, followed by drying for 4 hours. The 2nd and 3rd layers are prepared in the same way. Before and after impregnation, the color of the samples remains constant.

Then, the samples are weighed, and the data is entered in tables 1-3.

For fire resistance testing, a universal unit for determining the group of hard-to-burn materials and fire-resistant properties of coatings and impregnating compounds for wood processing "Ceramic tube" is used [10].

The tests are performed in the following order:
- the sample is placed in the clamping device and brought to the gas burner;
- the gas burner is switched on;
- after the sample is ignited, the gas burner switches off.

Similar actions are performed for all wood samples.

4. The results of the tests
The initial mass of the samples and the values obtained during the tests for each sample (mass after three penetrations and mass after testing of each sample, as well as the time of charring, smouldering and burning in minutes) are presented in tables 1,2,3.

Table 1. Main features indicators beech tree.

| Type of blank | Sample number | Sample initial mass(g) | Weight after impregnation(g) | Weight after test(g) | Charring (min) | Smouldering (min) | Burning (min) |
|---------------|---------------|------------------------|------------------------------|---------------------|---------------|------------------|---------------|
| Beech         | 1-1           | 46.800                 | 49.592                       | 40.300              | 0:30          | 0:40             | 1:20          |
|               | 1-2           | 45.969                 | 49.842                       | 43.600              | 0:40          | 1:45             | 2:00          |
|               | 1-3           | 45.563                 | 49.409                       | 43.890              | 0:20          | 0:30             | 1:06          |
|               | 1-4           | 45.146                 | 49.949                       | 40.510              | 1:46          | 1:58             | 4:53          |
|               | 1-5           | 45.235                 | 49.031                       | 40.430              | 1:10          | 1:47             | 3:20          |
|               | 1-6           | 45.532                 | 49.329                       | 43.740              | 0:30          | 0:45             | 1:18          |
|               | 1-7           | 46.800                 | 50.630                       | 47.800              | 0:20          | 0:35             | 3:05          |
|               | 1-8           | 45.046                 | 49.736                       | 45.120              | 0:45          | 1:05             | 2:20          |
|               | 1-9           | 46.570                 | 50.391                       | 45.390              | 0:25          | 0:35             | 1:33          |
| Average value |               | 45.851                 | 49.767                       | 43.422              | 0:25          | 1:04             | 2:19          |

Table 2. Basic indicators of birch trees.

| Type of blank | Sample number | Sample initial mass(g) | Weight after impregnation(g) | Weight after test(g) | Charring (min) | Smouldering (min) | Burning (min) |
|---------------|---------------|------------------------|------------------------------|---------------------|---------------|------------------|---------------|
| Birch         | 2-1           | 36.054                 | 42.680                       | 30.230              | 0:30          | 0:35             | 1:40          |
|               | 2-2           | 34.537                 | 40.690                       | 31.610              | 0:23          | 0:45             | 1:03          |
|               | 2-3           | 34.700                 | 40.095                       | 30.900              | 0:24          | 0:35             | 2:56          |
|               | 2-4           | 34.710                 | 40.903                       | 27.210              | 0:15          | 0:17             | 0:23          |
|               | 2-5           | 33.909                 | 39.799                       | 30.400              | 0:15          | 1:10             | 1:10          |
|               | 2-6           | 35.071                 | 41.367                       | 35.700              | 0:25          | 0:32             | 1:13          |
|               | 2-7           | 33.778                 | 39.650                       | 23.300              | 0:15          | 0:20             | 1:00          |
|               | 2-8           | 35.488                 | 41.281                       | 34.280              | 0:15          | 0:18             | 0:20          |
|               | 2-9           | 35.235                 | 41.330                       | 35.400              | 0:17          | 0:23             | 1:03          |
| Average value |               | 34.831                 | 40.866                       | 31.003              | 0:20          | 0:33             | 1:00          |
Table 3. Basic indicators of pine trees.

| Type of blank | Sample number | Sample initial mass (g) | Weight after impregnation (g) | Weight after test (g) | Charring (min) | Smouldering (min) | Burning (min) |
|---------------|---------------|-------------------------|-------------------------------|----------------------|---------------|------------------|---------------|
| Pine          | 3-1           | 26.935                  | 32.836                        | 23.360               | 1:30          | 6:00             | 8:18          |
|               | 3-2           | 28.410                  | 34.129                        | 26.580               | 2:35          | 19:00            |               |
|               | 3-3           | 30.353                  | 36.684                        | 25.140               | 2:30          | 4:05             | 7:20          |
|               | 3-4           | 28.168                  | 34.321                        | 30.080               | 3:00          | 13:00            | 23:00         |
|               | 3-5           | 28.032                  | 34.127                        | 30.690               | 1:00          | 5:00             | 13:40         |
|               | 3-6           | 28.026                  | 34.993                        | 30.020               | 1:00          | 2:00             | 15:50         |
|               | 3-7           | 28.362                  | 34.056                        | 30.450               | 0:50          | 1:00             | 1:10          |
|               | 3-8           | 31.831                  | 37.044                        | 30.780               | 0:40          | 1:20             | 2:20          |
|               | 3-9           | 29.093                  | 35.361                        | 25.300               | 1:50          | 2:00             | 3:50          |
| Average value |               | 28.821                  | 34.839                        | 28.044               | 2:02          | 6:32             | 8:30          |

Also, the indicators obtained during the tests for each sample of beech, birch and pine are presented graphically (Figures 1, 2, 3).

The arithmetic mean value of mass loss of 9 beech samples was 12.7 %, which corresponds to the 2nd group of fire-resistant efficiency of the tested fire-resistant coating with this method of its application (Figure 1).

![Figure 1](image.png)

**Figure 1.** The time of smouldering, burning and charring of beech samples.

The arithmetic mean value of mass loss of 9 birch samples was 24.1 %, which corresponds to the 2nd group of fire-resistant efficiency of the tested fire-resistant coating with this method of its application (Figure 2).
Figure 2. The time of smouldering, burning and charring of birch samples.

The arithmetic mean value of mass loss of 9 pine samples was 19.4 %, which corresponds to the 2nd group of fire-resistant efficiency of the tested fire-resistant coating with this method of its application (Figure 3).

Figure 3. The time of smouldering, burning and charring of pine samples.

5. Conclusion
For all the tested samples of wood species, a group of fire-resistant effectiveness of fire-resistant coating was established for this method of applying it. Water-based impregnation with soda ash and boric acid was most effective on beech samples. Achieving the proper quality of wood impregnation is
impossible without appropriate control of the moisture content of samples, the depth of impregnation, the quality of preparation of antiseptics or flame retardants. To do this, it is necessary to clearly determine the amount of absorbed substance (antiseptic or flame retardant), the depth of their penetration and the uniformity of distribution on the wood.

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