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BEHAVIOUR OF COATED WOOD TESTED IN A CONE CALORIMETER

The effects of non-fire-retardant coatings applied on Norway spruce in case of fire

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ABSTRACT: In order to increase the durability, as well as for optical reasons timber is often subjected to a surface treatment. The surface treatments can be roughly divided into two different types - in lacquers and stains.
Previous studies with fire retardant coatings aroused the interest to investigate the influence of normal, non-fire-retardant coatings on the combustion behavior of wood in case of fire. There is also interest from paint manufacturers, as well as building physicists to investigate the effects of surface treatments on the combustion behavior.
The investigation is performed using a cone calorimeter according to ISO 5660. In the wood samples thermocouples are installed in two layers. The heat flux exposure is 50 kW/m² during a test duration of 720 seconds (12 minutes).
In this article, the temperature evolution, the mass loss rate (MLR), the heat release rate (HRR) and the released energy (THR – Total heat release) of four lacquers and two stains is compared with untreated wood.

KEYWORDS: Cone calorimeter, coatings, temperature development, mass loss rate, heat release rate, total heat release

1 INTRODUCTION

Wood is nature´s versatile building material. It has minimal environmental pollution and a range of excellent technical properties. For centuries, wood has been used in construction both structurally and as a decorative material. Due to its natural combustibility, timber burns if exposed to severe fire conditions [2]. To increase fire resistant or durability as well for optical reasons timber is often subjected to a surface treatment.
Studies with fire retardant coatings are already listed in literature [1], [2], [3], [5], but there is a lack of knowledge about the fire behaviour of normal, non-fire-retardant coatings.
The behaviour under fire conditions of six different non-fire-retardant coatings applied on spruce are described in this paper with parameters like mass loss rate (MLR), heat release rate (HRR) and total heat release (THR).

2 MATERIALS

Seven test series were investigated and for each test series three replications were performed. The investigation include two water soluble Acryl based coatings, two synthetic resin based coatings, two water soluble stains and the reference test series. Two layers of each coating were applied with an intermediate abrade using a P280 sandpaper. Each test series were cut out of the same three boards of clear wood Norway spruce (Picea abies) samples. The underlying wood was selected in that way to have twin samples and the influence on the natural wood properties is minimized. The details of the used materials can be found in Table 1.

After the application of the coating the spruce samples were conditioned at laboratory conditions at 65 % RH and 20 °C for at least four weeks before to testing to reach equilibrium moisture content (EMC) [2].

Table 1: *Properties of the test materials*

Test series	Treat-ment	Colour	Mean density	Mean moisture
B1	Acryl lacquer	white/ gray	419,00 kg/m³	9,9%
B2	Acryl lacquer	white	422,15 kg/m³	10,0%
B3	Resin lacquer	white	422,81 kg/m³	10,0%
B4	Resin lacquer	white	420,78 kg/m³	10,1%
B5	Stain	larch	419,90 kg/m³	10,1%
B6	Stain	larch	422,86 kg/m³	10,0%
REF	-	-	422,66 kg/m³	9,8%

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3 TEST FACILITY

To obtain a closed system, a mass loss cone is placed in a conditioning cabinet. Two pipes are fixed on the conditioning cabinet. In each pipe the gas flow velocity and the gas temperature are measured. In the exhaust pipe, on the top of the conditioning cabinet, the exhaust gas components are measured with a flue analyser, too. The measured values of the flue analyser are the content of oxygen, carbon monoxide, carbon dioxide and carbon hydrates. Furthermore, the mass of the sample and temperatures in different layers of the sample are measured. The measured values are recorded each second [2], [3].
With this arrangement it is possible to make investigations according to ISO 5660 [4].

4 FIRE TESTS

The test dimensions of the test samples are 100 x 100 mm with a thickness of 30 mm. The annual ring orientation of the sample is perpendicular to the thermal exposure. Before testing the specimen were wrapped into aluminium foil to approximate real scale moisture transport behaviour. Then the specimen is placed in a sample holder, which is positioned on a balance. The top of the specimen is located 25 mm under the bottom of the conical heater. The area of the sample, exposed to the radiation, is 0.009 m². A split shutter mechanism protects the area of the sample before the test starts. The shutter is manually opened with a mechanical lever [2]. A trigger, mounted on the lever, starts the test. Test begin, t = 0 is defined by the moment the shutter is opened exposing the specimen to the radiant heat flux. The heat flux exposure is 50 kW/m² during a test duration of 720 seconds.

5 RESULTS

The test results, presented in the final paper, are the time to ignition, the mass loss rate (MLR), the heat release rate (HRR), the total heat release (THR) and the temperature development for a test duration of 720 seconds.

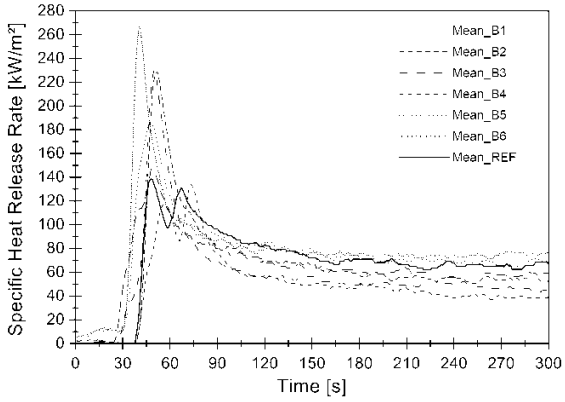

Figure 1: *Specific heat release rate (HRR)*

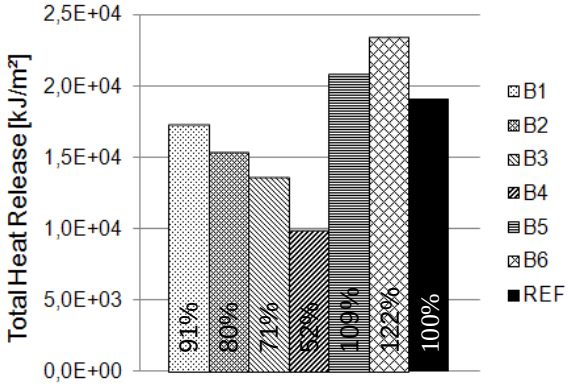

Figure 2: *Total heat release after 600 seconds (THR_{600})*

There are large differences in the maximum value of the heat release rates, shown in Figure 1. But also in steady-state combustion behaviour, after about 180 seconds, differences can be seen.
Integrating the HRR over 600 seconds results the THR_{600}. The THR_{600} varies between 52% (resin lacquer) and 122% (stain) in comparison to the reference sample (see Figure 2).
A complete comparison of the different coatings applied on Norway spruce to untreated wood will be made in the final paper using diagrams and tables (see Figure 1 and Figure 2).

6 CONCLUSIONS

The large differences in the THR_{600}, examined in the cone calorimeter, result in large differences in real fire load. The results clearly show significant effects on the combustion behaviour even after more than 120 seconds (ignition phase) for surface treated wood.
More detailed conclusions will be made in the final paper.

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