ŽILINSKÁ UNIVERZITA V ŽILINE
Fakulta bezpečnostného inžinierstva

28. medzinárodná vedecká konferencia

RIEŠENIE KRÍZOVÝCH SITUÁCIÍ V ŠPECIFICKOM PROSTREDÍ

15. - 16. október 2025
Žilina

Žilinská univerzita v Žiline

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Príspevky recenzovali vždy dvaja nezávislí recenzenti.

ISBN 978-80-554-2234-3

FIRE PROTECTION OF WOOD BASED ON MULTICOMPONENT MIXTURES OF SUBSTANCES

PROTIPOŽIARNA OCHRANA DREVA NA BÁZE VIACZLOŽKOVÝCH ZMESI LÁTOK

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ABSTRACT

Analysis of scientific, technical, and patent literature highlights the relevance of further research aimed at developing new, more effective and economically attractive three-component mixtures of substances to be used as fire-extinguishing and fire-protective agents for wood. The composition (active basis) of the three-component systems was visualized using the Gibbs–Rosenbaum method. An equilateral triangle was constructed for this purpose, with its sides calibrated to represent component percentages in 20% increments. After obtaining the efficiency for each point, the data were entered into the matrix of the Statsoft Statistica software. This program was then used to construct an additive surface, the efficiency surface of the three-component mixture, a zone map, and a contour plot. Additionally, the equation describing the dependence of the mixture's efficiency on its composition was derived. To investigate the effectiveness of fire-extinguishing powders, a laboratory setup with a Bunsen burner was used. A mathematical calculation was performed to determine the predicted increase in the fire-extinguishing efficiency of powder E_2 when preheated to a specific temperature t_2, given its known fire-extinguishing efficiency E_1at a lower ambient temperature t_1.

$$E_2 = E_1 + \left(22 \cdot t_{пл}^{\ -0,75} + 0,45\right) \cdot \left(t_2 - t_1\right) \qquad (1)$$

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Research was conducted on the effect of nitrogen-containing compounds (carbamide, urotropin, and diphenylamine) on the effectiveness of fire-extinguishing powders. The results indicate that it is possible to enhance the efficiency and create more advanced fire-extinguishing and fire-protective compositions for wood. This can be achieved by using mixtures of inorganic salts with inhibitors of low-temperature oxidation (amines). An investigation into the flame-inhibiting effects of aqueous solutions of ammonium sulfates, phosphates, and carbamide was conducted using optical spectroscopy. The study determined that these inorganic salt solutions significantly inhibit the combustion process. Their strong inhibiting effect suggests they can be effectively used for the fire protection of cellulose-containing materials, such as wood. To determine the temperature range at which the thermal destruction of salts occurs most intensely, thermogravimetric studies of the thermal degradation processes were conducted. These studies revealed the mixtures' ability to cool wood from 164 °C. The results of gas chromatographic studies on the pyrolysis of untreated and treated wood with fire retardants based on monoammonium phosphate, ammonium sulfate, and carbamide indicate that significantly fewer combustible gases, especially hydrogen, are released from the treated wood. To establish the fire-retardant properties of wood treated with mixtures based on monoammonium phosphate and carbamide, as well as with mixtures of monoammonium phosphate, ammonium sulfate, and carbamide, experimental studies were conducted to determine the mass loss of samples after fire tests. The treated wood samples showed high fire-retardant effectiveness. The influence of two-component compositions of a fire retardant and an intumescent additive (monoammonium phosphate: carbamide, and monoammonium phosphate: carbamide-formaldehyde resin on the flammability of epoxy polymers was investigated using the "fire tube" method. The results showed that with the combined application of fire retardants and these additives, the tested materials transition into the group of non-combustible materials. To test the fire-protective coating for wood based on epoxy-polymer binders, experimental studies were conducted to determine its fire-retardant effectiveness. As shown by the results, the coatings with mixtures of monoammonium phosphate and carbamide, and monoammonium phosphate and carbamide-formaldehyde resin, demonstrated the highest fire-retardant effectiveness. A synergistic effect was also established for two- and three-component fire-extinguishing powder mixtures when one of the components is an amine. Thermal analysis of multicomponent mixtures showed that a two-component mixture of monoammonium phosphate and ammonium sulfate is thermally stable up to 200°C. In contrast, a three-component mixture of monoammonium phosphate, ammonium sulfate, and carbamide exhibits significant endothermic effects in the temperature range of 120°C to 165°C. Thermogravimetric studies demonstrated that the use of a mixture of monoammonium phosphate and carbamide-formaldehyde resin as an additive to epoxy polymers leads to a reduction in the oxidation rate of the carbonized residue at temperatures between 500°C and 600°C. Specifically, the oxidation rate was reduced by 1.4 times compared to a mixture of monoammonium phosphate and carbamide,

and by 2 times compared to a mixture of monoammonium phosphate and carbamide-formaldehyde resin alone. This makes the monoammonium phosphate and carbamide-formaldehyde resin mixture a more effective fire-protective coating for wood.

Key words:
firefighting powder, fire efficiency, gas chromatography, epoxy polymer, non-additivity.

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Názov **RIEŠENIE KRÍZOVÝCH SITUÁCIÍ V ŠPECIFICKOM PROSTREDÍ**
zborník abstraktov z 28. vedeckej konferencie s medzinárodnou účasťou

Zostavovateľ doc. Ing. Michal Titko, PhD.
Vydala Žilinská univerzita v Žiline v EDIS-vydavateľstve UNIZA
Vydanie prvé, 2025, rozširované elektronicky

Za obsah a úpravu abstraktov zodpovedajú autori.

Spracované podľa dodaných predlôh.

ISBN 978-80-554-2234-3