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Obsah

Stanovenie zápalnosti v teplovzdušnej peci vybraných celulózových materiálov

Determination of Ignition Temperature Using a Hot-Air Furnace of Selected Cellulose Materials

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Abstrakt

Ochrana pred požiarmi ako súčasť problematiky ochrany obyvateľstva má svoje opodstatnenie pri predchádzani a minimalizovaní pravdepodobnosti vzniku požiarov a ich následkov a to aj v rôznych kategóriách stavebných objektov ako sú napr.: priemyselné, výrobné a technologické stavby, sklady a iné. V technológií výroby a spracovania papiera - konkrétne tissue papiera zo základných vstupných surovín: buničiny a zberového papiera, patrí operácia rozvlákňovania, spojená s úpravami a odstraňovaním neželateľných tlačiarenských farbív k najrizikovejším z hľadiska vzniku požiaru. Pri bielení dochádza ku kontaktu horľavých vstupných surovín (napr.: zberového papiera, buničiny) a silného oxidačného prostriedku - peroxidu vodíka, ktorý sám o sebe nie je horľavý, ale výrazne podporuje proces horenia, a tým zvyšuje požiarne nebezpečenstvo v operácií rozvlákňovania pri príprave papieroviny, v technologickom procese výroby papierenských tissue produktov: hygienického toaletného papiera, hygienických obrúskov a vreckoviek. Používaný bieliaci prostriedok peroxid vodíka je možné v praxi nahradiť za inú, vhodnejšiu a z požiarneho hľadiska bezpečnejšiu látku. Danou látkou je enzým, ktorý spôsobuje účinnejšie enzymatické bielenie vstupnej suroviny zberového papiera. Cieľom experimentálneho skúmania bolo overenie a porovnanie vplyvu bieliacich prostriedkov, peroxidu vodíka a enzýmu na zapáliteľnosť celulózových materiálov. Predmetom skúšky sú vzorky vstupných surovín - zberového papiera, buničiny a medziproduktov - tissue papiera. Boli stanovené a porovnané konkrétne požiarnotechnické charakteristiky teplota vzplanutia a teplota vznietenia vybratých celulózových materiálov metódou STN ISO 871:1999. Plasty. Stanovenie zápalnosti v teplovzdušnej peci. Teoretické a praktické skúmanie na základe experimentov v oblasti horenia celulózových materiálov prinášajú nové poznatky, ktoré je možné aplikovať do praxe, s cieľom zníženia požiarneho nebezpečenstva v papierenskej technológií výroby.

Kľúčové slová

Horenie celulózových materiálov, zberový papier, tissue papier, bod vzplanutia, bod vznietenia.

Abstract

Fire protection issues as part of public protection is justified in preventing and minimizing the likelihood of fires and their consequences, and even in different categories of buildings sucha s.: industrial, manufacturing and technological buildings, warehouses and others. Pulping operation in technology of paper production and procession, factually of tissue paper from basic input raw materials, associated with treatment and disposal of unwanted printing dyes belongs, to the most risky in terms of fire. During bleaching process contact of flammable input raw materials (e.g. waste paper, cellulose) with strong oxidizing agent - hydrogen peroxide takes place. Hydrogen peroxide itself is not flammable but significantly supports burning process and thus increases fire danger in pulping operation at pulp cellulose preparing and in technological process of production tissue paper products: hygienic toilet paper, hygienic napkins and handkerchiefs. Used bleaching agent, hydrogen peroxide, is possible to substitute by other more suitable and more fire safety substance in practice. This substance is an enzyme that causes more effective enzymatic bleaching of waste paper input raw material. The goal of experimental investigation was verification and comparison of effect of bleaching agents (hydrogen peroxide and enzyme) on cellulose material inflammability. Subjects of tests werw input raw material samples - waste paper, wood pulp and intermediary product - tissue paper. Namely, following fire technical parameters: flash ignition temperature and self-ignition temperature of selected cellulose materials were determined and compared by method in STN ISO 871:1999 Plastics. Determination of ignition temperature using a hot-air furnace. Theoretical and practical investigations based on experiments concerning combustion of cellulose materials bring new knowledge.

Keywords

Burning of cellulose materials, waste paper, tissue paper, flash ignition temperature, self-ignition temperature.

Introduction

Protection of the population is a complex of preparation and in emergencies and crisis situations practically implemented measures. The measures are in line with current legislation and ensure utmost protection of health, life and animal population, material and cultural values as well as the environment, taking into account the economic capacity of the state. Public protection measures are carried out individual components Integrated Rescue System, especially Fire and Rescue SR. Fire in the different buildings and their subsequent localization and disposal are also part of the complex issue of public protection. Current legislation in force stipulates that fire safety topic solved almost in each building structure because it is necessary to secure not only sufficient level of fire safety but also protection of health and lives of people. The principal goal is to minimize probability of fire origin and its possible consequences by applying suitable fire precaution measures, elements, systems and equipment and thus improve and increase fire safety [1, 2]. In the Slovak Research and Development Agency (APVV) Project APVV-0727-12 “Model for increasing of economic effectiveness of fire precaution measures”, the solving team at the Faculty of Security Engineering of the University of Žilina solves topic of economiceffectiveness evaluation of fire precaution measures by practically applicable model. Evaluation of effectiveness of financial sources spent on particular fire protection elements, systems and equipment, their procurement and maintenance following from their application in various building structures plays a dominant role in resolving this issue. Data obtained from the Project will be applicable in practice and will result in improving fire safety level and improving financial sources required for its implementation [3, 4]. Structural fire safety depends on many factors:e.g. on amount and type of flammable products, materials and substances placed in those. In building structures and in technologies, too, flammable cellulose materials are present frequently [5 - 25], (for example wood, wood pulp, cellulose, paper, waste paper, tissue paper, etc.) In technology of paper production and processing, namely of tissue paper from basic input raw materials: wood pulp and waste paper, pulping operation connected with treatment and removal of unwanted printing dyers belongs to the most hazardous as regards possible origin of fire. During bleaching, contact flammable input

raw materials (wastw paper) and strong oxidizing agent, hydrogen peroxide, takes place. Hydrogen peroxide itself is not flammable but significantly supports burning process and thus increases fire danger in pulping operation at pulp cellulose preparing and in technological process of production tissue paper products: hygienic toilet paper, hygienic napkins and handkerchiefs [5 - 25]. It is possible to substitute used bleaching agent, hydrogen peroxide, by other more suitable and more fire safety substance in practice. This substance is an enzyme that causes more effective enzymatic bleaching of waste paper input raw material. Presence of cellulose materials as well as products significantly influences burning process thus i tis important to know their fire technical parameters, for example the flash ignition temperature and self-ignition temperature. Values of the flash ignition temperature and self-ignition temperature are determined by the standardized method STN ISO 871:1999 Plastics: Determination of ignition temperature using a hot-air furnace [9, 10, 12]. Measured results can serve for comparison and assessment of fire origin possibility in technology of tissue products production focused on a bleaching process by two different methods- the peroxide one and the enzymatic one. Effect of used bleaching agents (hydrogen peroxide and enzyme) on inflammability of completed tissue products will be evaluated: that finally affects solving of fire protection topic in various building structures, namely in technological process of tissue product production [9, 10, 12].

Inflammability in a hot-air furnace

Fire technical characteristics - flash ignition temperature and self-ignition temperature of selected cellulose materials are to be determined and compared by method of STN ISO 871:1999 Plastics: Determination of ignition temperature using a hot-air furnace. This standard STN ISO 871 refers to the laboratory method of determination of ignition temperature using a hot-air furnace [9, 10, 12, 26 - 32]. This method is not used for description or evaluation of fire hazard nor fire risk of materials, products or equipment under specific fire conditions. Results of this test can be used as elements of fire hazard estimation when all factorsb relating to fire hazard estimation in any specific case are taken into account. Tests carried out under this method conditions have relevant significance at comparison of relative flammability characteristics of different materials. Obtained results represent the lowest temperature of ambient atmosphere when inflammability of material occurs under test conditions. Measured values allow arranging materials according to their susceptibility for inflammability under common use conditions. Determination of inflammability in a hot-air furnace is a suitable test also for polymeric materials on cellulose base [9, 10, 12, 26 - 32].

Flash ignition temperature (FIT) is the lowest temperature at which, under specified test conditions, sufficient flammable gases are emitted to ignite momentarilyon application of a pilot flame [9, 10, 12, 14].

Spontaneous-ignition temperature (SIT) is the lowest temperature at which, under specified test conditions, ignition is obtained by heating in the absence of any additional ignition source [9, 10, 12, 14].

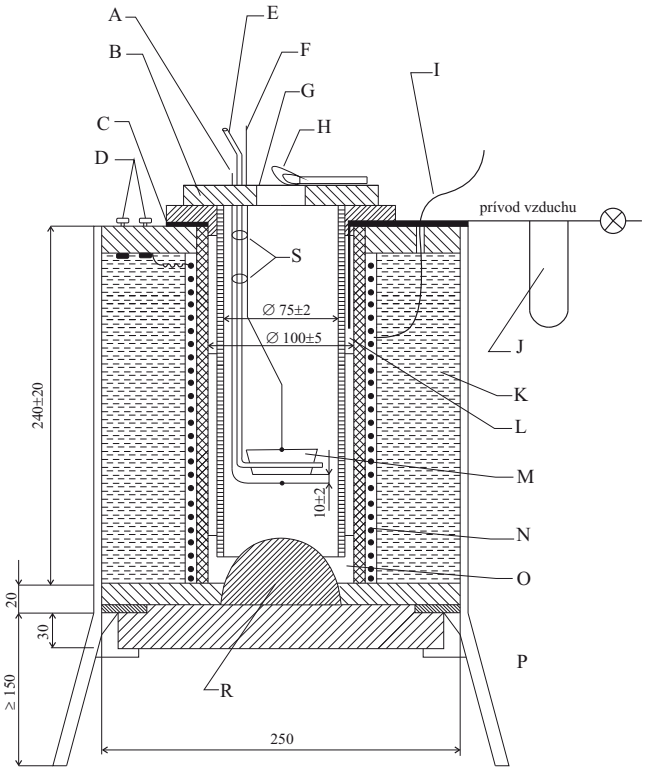

Fig. 1 Cross-section of the hot-air furnace [9]
A - thermocouple TC_2, B - fire-resistant disc cover, C - sealing ring, D - terminals of heating spiral, E - support rod, F - thermocouple TC_1, G - opening (diameter 25 mm), H - pilot flame, I - thermocouple TC_3, J - air-flow meter, K - mineral fibre wool, L - air-flow tangential to cylinder, M - specimen pan, N - 50-turns of No 16 Nichrome wire in heat resistant tunnel, O - three distant blocks to spice inner tube location and support it, P - thermal insulation, R - inspection plug, S - metal fastening clamps

Tab. 1 Essential data on cellulose materiál specimens [12, 33, 34]

Specimen identification	Essential data	Note (represented by)
A - input raw material	Mixture of waste paper; group quality C^a - input raw material; better quality types	white newspaper; journals and newspaper with minimum text, pieces of paper sheets and cut white colour stripes printed by minimum text
B - input raw material	Mixture of waste paper; group quality B^a - input raw material; middle quality types	journals and newspapers, pieces of paper sheets and cut white up to yellow colour stripes printed by text
C - intermediary product from 100 % wood pulp	Tissue paper - intermediary product made from 100 % wood pulp	non-bleached tissue paper suitable for production of final hygienic tissue products
D - intermediary product from waste paper bleached by enzyme	Tissue paper - intermediary product made from mixtures of waste paper (C^a 30 % + 70 % B^a) by enzymatic bleaching	tissue paper made from mixtures of waste paper bleached with enzyme and suitable for production of final hygienic tissue products
E - intermediary product from waste paper bleached by peroxide	Tissue paper - intermediary product made from mixtures of waste paper (C^a 30 % + 70 % B^a) by peroxide bleaching	tissue paper made from mixtures of waste paper bleached with peroxide and suitable for production of final hygienic tissue products

Note:
Waste paper according to the standard STN EN 643 is divided into four main groups in which more subgroups are defined; the A group: types of lower quality; the B group: types of middle quality; the C group: higher quality types; and the D group: types containing sulphates [12, 33, 34].
B^a - mixture of waste paper from the B group: middle quality types, actually it was represented by old newspapers [12, 33, 34].
C^a- mixture of waste paper from the C group: middle quality types, actually it was represented by a mixture of printing scraps wi th bright multi-coloured colours [12, 33, 34].

Principle of the test, testing apparatus and specimens

A specimen of the material (Tab. 1) is heated in the hot-air furnace within a heating chamber using various temperatures. Flash ignition temperature is determined by is determined with a small pilot flame directed at the opening in the top of the furnace to ignite evolved gases. The spontaneous-ignition temperature is determined in the same manner as the flash-ignition temperature, but without the pilot flame [9, 10, 12, 26 - 32]. The hot-air furnace and its cross-section is in Fig. 1 as a part of testing apparatus intended for determination of inflammability according to the STN ISO [9, 12]. The goal of investigation is verification and comparison of bleaching agents (hydrogen peroxide and enzyme) effect on inflammability of cellulose materials. Subjects of test are specimens of input raw materials - waste paper, and intermediary product - tissue paper [12, 33, 34] detailed referred to in the Tab. 1.

Preparation of tested specimens

Prior to the test, Specimens A, B, C, D, E were adjusted in roll forms with the mass (3,0 ± 0,2) g and tied by a wire and conditioned at the temperature (23 ± 2) °C and the relative humidity (50 ± 5) % for 40 hours in accordance with ISO 291 [12, 34].

Evaluation of experimental results and discussion

Measured values of the flash ignition temperature and spontaneous ignition temperature of cellulose material specimens are referred to in the Tab. 2 and shown in graphic form in the Fig. 2 [12, 34].

Tab. 2 Measured values of the flash ignition temperature and spontaneous ignition temperature of cellulose material specimens [12, 34]

Specimen - material	Essential data	Flash ignition temperature [ºC]	Spontaneous ignition temperature [ºC]
A - input raw material	Mixture of waste paper; group quality C[a] - input raw material; better quality types	310	430
B - input raw material	Mixture of waste paper; group quality B[a] - input raw material; middle quality types	320	410
C-intermediary product from 100 % wood pulp	Tissue paper - intermediary product made from 100 % wood pulp	270	420
D-intermediary product from waste paper bleached by enzyme	Tissue paper - intermediary product made from mixtures of waste paper (C[a] 30 % + 70 % B[a]) by enzymatic bleaching	310	410
E-intermediary product from waste paper bleached by peroxide	Tissue paper - intermediary product made from mixtures of waste paper (C[a] 30 % + 70 % B[a]) by peroxide bleaching	260	410

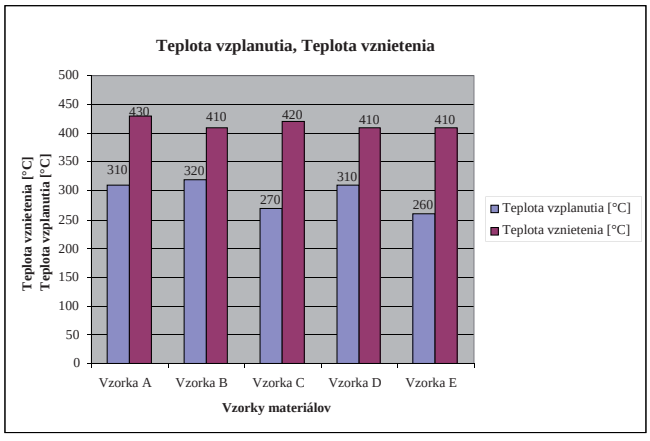

Fig. 2 Chart of measured values of the flash ignition temperature and spontaneous ignition temperature of cellulose material specimens [12, 34]

Discussion on experimental results - flash ignition temperature:

Measured values of the flash ignition temperature (referred to in the Tab. 2 and the Fig. 2), result in following: the highest flash ignition temperature value has the specimen B - 320 °C (mixture of waste paper; group quality B) and the lowest one has the specimen E - 260 °C (tissue paper made by peroxide bleaching). The specimen A - 310 °C (mixture of waste paper; group quality C) reaches value comparable with the specimen B. Results of measured values of specimens B, A, D, and C, actually B - 320 °C; A - 310 °C; D - 310 °C (tissue paper made by enzymatic bleaching); andC - 270 °C (tissue paper made without bleaching) are higher than the value of the specimen E - 260 °C. The flash ignition temperatures of the waste paper raw material - specimens B - 320 °C and A - 310 °C reached higher values probably due to presence of printing colouring. The specimen D - 310 °C (tissue paper made by enzymatic bleaching) reaches also high value of the flash ignition temperature when compared with specimen C - 270 °C (tissue paper made without bleaching) and specimen E - 260 °C (tissue paper made by peroxide bleaching.The difference between the flash ignition temperature of the specimens D vs. E is 50 °C that is not negligible [12, 34]. Probably more intensive bleaching processes at peroxide bleaching case may cause lower flash ignition temperature values for the specimen E; this means increasing of relative flammability of the Specimen E comparing with the specimen D that was bleached by enzyme. Based on measured values, it can be supposed that enzymatic bleaching of waste paper compared with the peroxide one, decreases flammability hazard of tissue paper, material intended for further processing and probably will decrease also flammability of final tissue products. It can be also stated that bleaching methods affect change of flash ignition temperature values as well as significantly change of relative flammability of all cellulose material specimens if naked heat source (flame) is used as an initiation source [12, 26 - 34].

Discussion on experimental results - spontaneous ignition temperature:

Measured values of the spontaneous ignition temperature (referred to in the Tab. 2 and the Fig. 2), result in following: the highest spontaneous ignition temperature value has the specimen A - 430 °C (mixture of waste paper; group quality C); followed by the specimen C - 420 °C (tissue paper made without bleaching) and the lowest value of the spontaneous ignition temperature reached specimens B, D, and E; specimen B - 410 °C (mixture of waste paper; group quality B); specimen D - 410 °C (tissue paper made by enzymatic bleaching); and specimen E - 410 °C (tissue paper made by peroxide bleaching). Measured spontaneous ignition temperature values of the input raw material - waste paper are higher in the specimen A - 430 °C than this in the specimen B - 410 °C; the specimen A contains more printing colourings than the specimen B that probably leads to increasing of the spontaneous ignition temperature value. This means that the specimen A will ignite at higher temperature of the ambient air flowing around than the specimen B. Tissue paper - intermediary material being further processed in final hygienic products reached the highest spontaneous ignition temperature value for the specimen

C - 420 °C followed by identical values of specimens D and E - 410 °C [12, 34]. Based on resulting values of the specimens D and E, it can be supposed that bleaching processes do not significantly influence the change of the spontaneous ignition temperature when compared with resulting values of the specimens A, B, and C. Values of samples D and E are only slightly lower (by 10 °C up to 20 °C) when compared with the specimens A, B, and C. It can be supposed that applying bleaching methods (specimens D and E) only slightly decreases the spontaneous ignition temperature and thus slightly increases relative flammability when compared with the specimen C represented by tissue paper without any bleaching. Overall, it can be quoted that bleaching methods have not significant effect on change of spontaneous ignition temperature values or on significant change of relative flammability of all cellulose material specimens if radiant heat source is used as an initiation source [12, 26 - 34].

Discussion on experimental results:

Comparison of determined parameter values: the flash ignition temperature and the spontaneousignition temperature of cellulose material specimens are referred to in the Tab. 2 and the Fig. 2. The flash ignition temperature values of cellulose materials are within the range from 260 °C up to 320 °C; these flash ignition temperature values of particular specimens A, B, C, D, and E are referred to in the Tab. 2 and the Fig. 2 - the graph. Determined values of the spontaneous ignition temperature of cellulose material specimens are within the range from 410 °C up to 430 °C; these values of particular specimens A, B, C, D, and E are referred to in the Tab. 2 and the Fig. 2 - the graph. Measured values of the spontaneous ignition temperature of cellulose material specimens A, B, C, D, and E are by 110 °C up to 150 °C higher than values of the flash ignition temperature of identical specimens [12, 34]. Lower values of the flash ignition temperature can be explained by naked direct ignition source (propane flame) having higher initiation energy than indirect ignition source - hot air flow (radiant heat) used for determination of the spontaneous ignition temperature. Flash ignition, flame burning and following extinction of the same cellulosic material occur first, at lower temperatures than the spontaneous ignition and continuous flame burning [12, 26 - 34].

Conclusions

Determined values of the fire technical characteristics: the flash ignition temperature and the spontaneous ignition temperature were measured according to the standard STN ISO 871 [9 ,12]. Based on determined results (Tab. 1 and 2 and Fig. 2), it can be stated that input raw material specimens - waste paper A and B, namely specimen A - waste paper of quality group C and specimen B - waste paper of quality group B, reached the highest values of monitored fire technical characteristics: the flash ignition temperature and the spontaneous ignition temperature. It can be assumed that presence of dyers, fillers, gluing agents and other additives decreases relative flammability of waste paper. Based on comparison of determined values of the fire technical characteristics of the specimens D and E (Tab. 2 and Fig. 2), the specimen D - tissue paper made by enzymatic bleaching; and the specimen E - tissue paper made by peroxide bleaching, it can be stated that tissue paper made from waste paper by enzymatic bleaching is less flammable than that made by peroxide bleaching. At the same time, it can be assumed that also final tissue hygiene products made by enzymatic bleaching are less flammable than tissue products made by peroxide bleaching [12]. Applying of enzymatic bleaching method (enzyme) during pulping when compared with peroxide bleaching method (hydrogen peroxide) decreases flammability of tissue paper and final tissue products that consequently affects decreasing of fire origin danger in the technological process of tissue product production. Measured results will contribute in practice to solving topic concerning decreasing of fire origin danger in paper-processing industry, namely at production of tissue paper and tissue hygienic products - toilet paper, hygienic handkerchiefs, napkins and dish-cloths. By suitable technology arrangement and treatment of selected characteristics of cellulose materials, fire danger relating to their technology processing and storage as well as flammability of final tissue products can be reduced. Investigation of fire technical characteristics of treated products based on polymeric cellulose materials can contribute to increasing of fire safety in various building structures, especially in technological processes of production and storage [12, 26 - 36]. Study of properties, especially fire-technical characteristics of different substances and materials that are found in industry, it is possible to prevent fires that are common undesirable incidents. Adverse crises situations are part of the solution to a complex issue of the protection of the population and critical infrastructure protection [35, 36].

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References

[1] BALOG, K. 1989.: Požiarne nebezpečenstvo plastov používaných v stavebníctve. In: *Horľavosť materiálov a nebezpečné pôsobenie splodín horenia*. Bratislava: MV a ŽP SR a SŠP 1989, s. 12.

[2] POLEDŇÁK, P. 2000.: The Protection of Dikes in Crises Situations. In: *11th International Scientific and Technological Military Engineering Conference on Engineering and Management in Crises Situations*. Military University of Technology, Warsawa 2000.

[3] PROJEKT číslo APVV-0000-12 s názvom (2013-2016): „Model na zvyšovanie ekonomickej efektívnosti protipožiarnych opatrení“.

[4] CONEVA, I. 2014.: Požiarovosť v Ruskej federácii za obdobie 2012 - 2008. In: *Požární ochrana 2014*. 3. - 4. září 2014. Ostrava: Sdružení požárního a bezpečnostního inženýrství. ISBN 978-80-7385-148-4. ISSN 1803-1803. s. 21-25.

[5] BLAŽEJ, A.; KRKOŠKA, P. 1989.: *Technológia výroby papiera.* ALFA Bratislava. Bratislava 1989, ISBN 80-05-00119-3.

[6] HNĚTKOVSKÝ, V. a kol. 1983.: *Papírenská příručka*. STNL Praha. Praha 1983.

[7] BUČKO, J. 1997.: *Chemické spracúvanie dreva*. Zvolen. TU Zvolen, 1997 ISBN 80- 228-0663-3.

[8] CONEVA, I.; LUSKOVÁ, M. 2006.: Nebezpečenstvo použitia peroxidu vodíka vo výrobnom procese. In: *Ochrana pred požiarmi a záchranné služby* [elektronický zdroj] 2. vedecko-odborná konferencia s medzinárodnou účastku. Žilina 2006. KPI FŠI ŽU Žilina. s. 25 - 33, ISBN 80-8070-539-9.

[9] STN ISO 871: 1999. Plasty. Stanovenie zápalnosti v teplovzdušnej peci. 1999.

[10] LITTOMERICKÝ, V.: *Prehľad skúšok horľavosti vykonaných na PTEÚ MV SR v Bratislave*.

[11] CONEVA, I.; ČAHOJOVÁ, Ľ. 2004.: Vyhodnotenie štatistických údajov o papierenskom priemysle. In: *Fórum mladých odborníkov protipožiarnej ochrany* [elektronický zdroj], 5. medzinárodný odborný seminár. Zvolen, 2004. Zborník referátov, Zvolen: Technická univerzita, 2004, ISBN 80-228-1354-0.

[12] CONEVA, I. 2008.: *Nebezpečenstvá vzniku požiaru pri výrobe produktov na báze celulózy* [dizertačná práca: elektronický zdroj - CD] / Iveta Coneva; školiteľ Katěřina Orlíková.- VŠB - TU Ostrava, ČR, Fakulta bezpečnostního inženýrství, Katedra požární ochrany; študijný odbor: Požární ochrana

a bezpečnost průmyslu, doktorský študijný program: Požární ochrana a bezpečnost, Ostrava: 2008, - 158 s. + Autoref. 34 s.

[13] FILIPI, B. 2003.: *Nauka o materiálu*. 1. vyd. Sdružení požárního a bezpečnostního inženýrství, Ostrava 2003. 18-19 s. ISBN 80-86034-11-6.

[14] STN EN ISO 13 943: 2000. Požiarna bezpečnosť. Slovník, apríl 2000.

[15] BALOG, K.; KVARČÁK, M., 1999.: *Dynamika požáru*. 1. vyd. Edice SPBI SPEKTRUM, sv. 22, Sdružení požárního a bezpečnostního inženýrství. Ostrava 1999. ISBN 80-86111 44-X.

[16] ORLÍKOVÁ, K.; ŠTROCH, P., 1999.: *Chémie procesu horení*. 1. vyd. Ostrava: Edice SPBI SPEKTRUM, sv. 18, Sdružení požárního a bezpečnostního inženýrství. Ostrava 1999. ISBN 80-611139-3.

[17] BARTLOVÁ, I. 2000.: *Nebezpeční látky I.* 1. vyd. Ostrava: Edice SPBI SPEKTRUM, sv. 24, Sdružení požárního a bezpečnostního inženýrství. Ostrava 2000, 151 s., ISBN 80-8611160-1.

[18] OSVALD, A. 1996.: *Hodnotenie požiarnej bezpečnosti materiálov a výrobkov z dreva*. Zvolen: TU DF,1996, 103 s. ISBN 80-28-0595-5.

[19] BALOG, K. 1999.: *Samovznietenie*. 1. vyd. Ostrava: Edice SPBI SPEKTRUM, sv. 21, Sdružení požárního a bezpečnostního inženýrství. Ostrava 1999. ISBN 80-86111-45-8.

[20] STEINLEITNER, M.D. a kol. 1990.: *Požárne a bezpečnostne technické charakteristické hodnoty nebezpečných látek*. Zväz PO ČSSR, Praha, 1990.

[21] CONEVA, I. 2006.: Skladovanie základnej vstupnej suroviny - zberového papiera vo výrobnej prevádzke. In: *Crisis management*, roč. 5, č. 1, ŽU Žilina FŠI, 2006. 17-20 s. ISSN 1336-0019.

[22] KAČÍKOVÁ, D.; NETOPILOVÁ, M.; OSVALD, A. 2006.: *Drevo a jeho termická degradácia.* Edice SPBI SPEKTRUM, sv. 45, Sdružení požárního a bezpečnostního inženýrství. Ostrava 2006, ISBN 80 86634-78-7.

[23] FENGEL, D.; WEGENER, G.; WOOD, P. 1984.: *Chemistry, Ultrastructure, Reactions*. Berlin, New York: Walter de Gruyter, 1984. p. 613.

[24] FUNAOKA, M.; KAKO, T.; ABE, I. 1991.: Condensation of lignin dutiny heating of wood. In: *Wood Science and Technology 24*, 1991. p. 277-288.

[25] ROWELL, R.M.; DUSOTY, A.R.; DEGROOT, F.W.; SHAFIZADEF, F. 1984.: Bonding fire retardants to wood: Part I. Thermal behavior of chemical bonding agents. In: *Wood and Fiber Science*, 16 (2), 1984, p. 214-223.

[26] ZACHAR, M.; MAJLINGOVÁ, A.; MARTINKA, J.; XU, Q.; BALOG, K.; DIBDIAKOVÁ, J.; POLEDŇÁK, P.; RYBAKOWSKI, M.; 2014.: Impact of oak wood ageing on the heat release rate and the yield of carbon monoxide during fire. *European journal of environmental and safety sciences: scientific journal of the European Science and Research Institute and the Association of Fire Engineering.* 2014. zv. Vol. 2, č. issue 1, s. 1-4. ISSN 1339-472X.

[27] BALOG, K.; TUREKOVÁ, I. 2000.: Sledovanie vplyvu retardačních úprav na tepelnú degradáciu celulózy. In: *CO-MAT-TECH 2000*, 8. medzinárodná vedecká konferencia, Trnava 2000, KEBI MTF TU Trnava, s. 299-304, ISBN 80-227-2117-4.

[28] ORÉMUSOVÁ, E. 2007.: Hodnotenie teploty vzplanutia vybraných druhov PUR pien. *Krízový manažment X/2007*. Žilina: FŠI, Žilinská univerzita v Žiline 2007. s. 90-93. ISSN 1336-0019.

[29] ORÉMUSOVÁ, E. 2008.: Teplota vznietenia poťahových textílií na báze bavlny a vlny. In: *Ochrana pred požiarmi a záchranné služby.* 3. vedecko-odborná konferencia s medzinárodnou účasťou. Žilina: Katedra požiarneho inžinierstva FŠI ŽU v Žiline 2008, s. 136-140, ISBN 978-80-8070-856-6.

[30] MARKOVÁ, I. 2003.: Hodnotenie horľavosti látok uplatňujúcich sa v izolačnej alebo tvarovej vrstve čaluneného výrobku. *Čalúnnické dni 2004*. Tu vo zvolene, s. 16-20. ISBN 80-288-1316-8.

[31] TUREKOVÁ, I. 2003.: Valuation of combustibility od selected polymers. In: *CO-MAT-TECH 2003*. Bratislava: STU, 2003, ISBN 80-227-1949-8.

[32] TUREKOVÁ, I.; BALOG, K.; MICHALÍKOVÁ, A. 2002.: Vplyv kyseliny trihydrogénboritej na horenie tepelne namáhanej celulózy. In: *CO-MAT-TECH 2002*, MtF STU Trnava. 2002. str. 390 - 394.

[33] STN EN 643: 1999. Zberový papier.1999.

[34] CONEVA, I.: *Vzorka a materiály z výrobnej firmy tissue výrobkov*.

[35] DVOŘÁK, Z.; BOC, K.; VIDRÍKOVÁ, D. 2014.: Informačný portál ochrany kritickej infraštruktúry v Slovenskej republike In: *Civilná ochrana: revue pre civilnú ochranu obyvateľstva.* ISSN 1335-4094. Roč. 15, č. 4 (2014), s. 54-56.

[36] ŠIMÁK, L. 2013.: Základná terminológia na úseku prevencie závažných priemyselných havárií. Vedecký redaktor: Miloslav Seidl. In: *Prevencia závažných priemyselných havárií* (vedecká monografia). Žilina: Žilinská univerzita, 2013. ISBN 978-80-554-0786-9. s. 9-28.