processes

Editorial

Special Issue: "The Design and Optimization of Fire Protection Processes"

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This Special Issue, entitled "The Design and Optimization of Fire Protection Processes", has been created to help readers gain new insights into the field of fire protection. The world's current situation, considering climate change and ongoing economic changes, brings new challenges in the field of fire protection. Fire hazards are related to the presence of combustible materials and the creation of suitable conditions for the initiation of the combustion process. Possessing a good knowledge of these processes provides a basis for the development of fire prevention measures.

In this Special Issue entitled "The Design and optimization of fire protection Processes", the high-quality contributions contained within focus on the latest advancements and processes related to the thermal degradation of renewable natural materials, processes of fire initiation, fire development, and heat propagation in fires, with some attention also being paid to certain software models. The papers within this Special Issue discuss the following topics: the processes applied for fires; fire testing (fire characteristics); fire dynamics and heat release; and fire protection.

The Processes applied for fires

Fires are dynamic systems with a set of physicochemical processes [1,2]. The above processes interact with each other on the basis of the identified fire phases [3,4]. The presence of flammable substances in open air environments increases the potential for the formation of a fire [5–7]. A suitable initiator starts the combustion process [8]. The subsequent steps depend on the amount of heat released [9] and other parameters that affect the combustion process [10]. One of these important parameters is the amount of oxygen required to realize the chemical reaction needed for a fire to occur [11,12]. The influence of the amount of oxygen and inert gas in the process of the multiple-bay fuel tank is discussed in the first contribution of this Special Issue.

Fire testing (fire characteristics)

In fire testing, fire characteristics are parameters that can help to evaluate the behaviour of the materials in a fire [13]. The parameters listed in fire tests are specific to each phase of a fire [14]. The initial parameters of a fire assessment include the initiation temperature and the time to ignition [15,16]. Contributions 2 and 3 study these initial fire parameters.

Subsequent fire development and/or fully developed fires [17] are assessed by the heat of combustion and calorific value [18,19], maximum temperature reached in the fire [20,21], mass loss [22], and rate of fire spread [23]. The final factors that need to be evaluated in fire assessments include the amount of smoke produced, the optical density of the smoke [24–26], and the methods used to extinguish the fire [27–29]. Research in the field has focused on conducting laboratory tests according to prescribed standards [30–32] or large-scale tests [33,34].

Dynamics of fire and heat release

The basic parameter monitored in the assessment of smoke dynamics in fire development is the heat release rate (HRR) [35–37]. This parameter quantifies the amount of heat

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produced by the pro-processes in a fire [38,39]. The role of dynamics is to track how a fire propagates in an open [40] or confined space [41,42]. Research in the field regarding this has rarely conducted through real experiments [43–45]. Most research has took the form of experiments to monitor "reaction-on-fire" parameters [46,47]. Contribution 4 is dedicated to this area of research, and in this paper, attention is drawn to the creation of software models, as in the work of other authors [48–50].

Fire protection

Fire protection is a very hot topic. Fire protection requirements are based on the general requirements in all areas [51]. Cohesion in terms of safety precautions is needed in the construction and operation of production and non-production facilities [52,53]. In general, the field of fire protection can be divided into two parallel units: the preventive field [54] and the field of emergency services [55] which are prepared to take rapid and effective measures to prevent the spread of fires and eliminate them in the event of a fire. Contributions 5 and 6 address the areas pertaining to fire protection mentioned above.

The above topics are also discussed in six articles within this Special Issue, which are presented according to the chronology of the topics presented in this manuscript. A full list of the contributions is provided below:

Contribution 1. Shao, L.; He, J.; Lu, X.; Liu, W. Optimization Study of Inert Gas Distribution for Multiple-Bay Fuel Tank. *Processes* **2023**, *11*, 2441. https://doi.org/10.3390/pr11082441
Contribution 2. Markova, I.; Giertlova, Z.; Jadudova, J.; Turekova, I. Monitoring the Ignition of Hay and Straw by Radiant Heat. *Processes* **2023**, *11*, 2741. https://doi.org/10.3390/pr11092741
Contribution 3. Jad'ud'ová, J.; Marková, I.; Šťastná, M.; Giertlová, Z. The Evaluation of the Fire Safety of the Digestate as An Alternative Bedding Material. *Processes* **2023**, *11*, 2609. https://doi.org/10.3390/pr11092609
Contribution 4. Martinka, J.; Rantuch, P.; Martinka, F.; Wachter, I.; Štefko, T. Improvement of Heat Release Rate Measurement from Woods Based on Their Combustion Products Temperature Rise. *Processes* **2023**, *11*, 1206. https://doi.org/10.3390/pr11041206
Contribution 5. Leitner, B.; Ballay, M.; Kvet, M.; Kvet, M. Optimization of Fire Brigade Deployment by Means of Mathematical Programming. *Processes* **2023**, *11*, 1262. https://doi.org/10.3390/pr11041262
Contribution 6. Ballay, M.; Leitner, B.; Jakubovičová, L. Design and Optimization of the Training Device for the Employment of Hydraulic Rescue Tools in Traffic Accidents. *Processes* **2023**, *11*, 1103. https://doi.org/10.3390/pr11041103

Contribution 1 discusses the processes applied for fires and presents research focusing on the fire suppression process, specifically on the inerting effect. This paper is about the distribution of inert gas for the multiple-bay fuel tank. The authors propose an optimization method based on the TOPSIS method to improve the entropy and weight of the multiple-bay fuel tank. They established an experimental inert gas distribution system to measure the velocity index and uniformity index. They implemented the results of the optimalization method on an inerting Boeing 747 aircraft, where the average velocity index improved by 3.01%, and the average uniformity index improved by 26.18%.

Fire characteristics and specifically the sizes of the potential fires that could be caused by flammable materials can be determined by conducting experiments. In regard to this, this Special Issue has two contributions, both about natural materials. Contribution 2 describes the results of a test conducted to determine the thermal degradation and ignition of hay and straw via radiant heat. This study involved investigating the effects of sample type (hay and straw) and sample quantity on the thermal degradation process, temperature increase within the samples, and ignition temperature of the samples as a function of time. The ignition temperature of hay was determined to be higher (407 °C) than that of straw (380 °C).

For Contribution 3, the experimental determination of digestate ignition temperature was carried out according to EN 50281-2-1 (1998) using a hotplate device. Different amounts of samples (3, 5, and 10 g) were monitored to track the course of thermal degradation. The results showed higher temperatures of thermal degradation in samples of additionally dried digestate, where these processes were observed earlier in terms of time. The aim of this study was to research the use of digestate as a bedding material, and 3 and 10 g samples of digestate were deemed not suitable as bedding materials due to the fire safety aspects of the material.

Fire dynamics and heat release cannot be investigated by only conducting experiments, as software tools are also needed. Contribution 4 highlights one of the most important fire characteristics (in principle): heat release rate (HRR). The authors of this contribution describe a method for measuring the individual HRRs of combustible products based on rises in temperature. This method has a fundamental problem with respect to predicting the temperature dependence of the heat capacities of combustible products and the thermal inertia of the measurement system. This problem was solved by training neural networks to predict molar heat capacity and the amount of substance (chemical amount) flow rate of combustion products in the cone calorimeter exhaust duct. Experimental data were obtained from six different wood species—birch, oak, spruce, locust, poplar, and willow woods—at heat fluxes ranging from 25 to 50 kW m^{-2}.

Two articles presented in this Special Issue focus on the methods and techniques of fire departments. Contribution 5 is thematically centred around "fire protection" and deals with research on the application of the selected methods of operational research among emergency services. The article has a theoretical part and a practical part. The aim of the theoretical part was to identify the most important aspects of a real system that should be taken into account whenever a rescue system is being redesigned or optimized. The practical part presents a short case study conducted with real data on the rescue service system in Slovakia, in which the results obtained are compared with the current deployment of firefighting units.

The design and design optimization of a training device for operators of a hydraulic rescue tool for use in traffic accidents was investigated by the authors of Contribution 6. This article includes research on processes for improving the technical procedures used in such situations. It is based on contained experimental results aimed at assessing the time required to cut through the structural parts of a vehicle—the "A" and "B" pillars—when using a hydraulic extrication tool.

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