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Editorial

Combustion and Fluid Mechanics, Advance in Fire Safety Science, Volume 1

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Fires remain a major risk with dramatic impacts on humans, buildings, structures, the environment, the economy, etc. This risk concerns a multitude of different applications, such as buildings, industries, transport and infrastructure, vegetation, etc.

The reinforcement of fire safety management is an essential topic, and a significant improvement in the development of fire safety engineering is needed. This approach involves both experimental and numerical model investigations. However, fires are quite complex phenomena, and, as such, the combination of several competences, such as thermal exchanges, thermodynamic, fluid mechanics, and chemistry, is needed.

In this context, the present Special Issue aims to address the recent efforts and advances in fire safety science. A total of seven papers are presented, and they are a good illustration of the breakthrough research on all fire safety science, including experimental and numerical studies, both concerning the thermal decomposition of solid fuel, fire development and propagation, smoke propagation, and fire extinction.

Recent works have demonstrated the importance to consider with a detailed approach the thermal decomposition since it represents the source term of all combustion process of the solid fuels. Thus, Batiot et al. [1] demonstrated that the Arrhenius relation, developed for gas combustibles, can be applied in the solid phase in order to describe the kinetics of the thermal decomposition of solid fuels. These authors also presented a critical analysis of the existing thermal degradation models to evaluate the implications of using an Arrhenius-type equation to quantify mass-loss rates and gaseous fuel production for fire predictions.

Scandeli et al. [2] presented new efforts on the modelling of the coupling between the solid phase (thermal decomposition) and the gas phase (gaseous combustion) during the combustion process of wood. They proposed a numerical framework that couples a detailed three-dimensional pyrolysis model and fire foam.

The work of Chaudhari et al. [3] completed the precedent studies. It concerns the study of the flammability of one representative example of polyisocyanurate (PIR) foam using experiments and modeling at various scales. A complete pyrolysis property set was developed and shown to accurately predict the results of all aforementioned measurements. A modeling approach based on the coupling between detailed pyrolysis simulations and a spatially resolved relationship between the total heat release rate and heat feedback from a flame was found to predict the evolution of the heat release rate measured in full-scale tests on the PIR foam.

Concerning flame propagation, an experimental and numerical study was conducted by Beshier et al. [4] to reduce fire spread risk by decreasing the length of flames and radiation from external plumes at vertical openings. It was found that adding horizontal openings decreased the average heat flux measured at the door, and the computational fluid dynamics (CFD) model successfully captured the main fire dynamics within the compartment.

Although submissions for this Special Issue have been closed, more in-depth research in the field of fire safety science continues to address the numerous challenges we face today in order to prevent them, predict them, and limit their impact.

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Because heat transfer is one of the main parameters of fire science, the paper written by Maragkos [5] focuses on convection, and the authors reviewed the most commonly used approaches for modelling convective heat transfer with CFD, using large-eddy simulations (LES) in the context of fire-driven flows, including pool fires and turbulent wall fires. The main assumptions, advantages, and disadvantages of each modelling approach are outlined. Finally, a selection of numerical results from the application of different approaches in pool fire and flame spread cases is presented in order to demonstrate the impact that convective heat transfer modelling can have in such scenarios.

All the precedent studies were completed by the contribution of Porterie et al. [6], whose work concerns the development and validation of a new and original two-zone model (taking into account the effects of ceiling jets on the convective heat transfer to enclosure walls and, unlike existing models, a new concept of a surrogate fuel molecule (SFM) to model multi-fuel combustion and a momentum equation to accurately track the displacement of the smoke layer interface over time) to predict fire development in a compartment. The model results are successfully compared to the experimental data obtained from full-scale fire experiments.

Finally, the paper written by Mahmud et al. [7] deals with the extinction process of fire. Because the physical characteristics of water sprays (notably, the median diameter of water droplets) profoundly influence the efficacy with which fires are extinguished, this study presents a computational fluid dynamics (CFD) program to estimate the median diameter of water sprays.

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