PhD Position
« Improvement of numerical modeling of the fire reaction of solid materials. Application to fire safety engineering studies ».
Institut Pprime – Université de Poitiers – Efectis France

1. Context of the PhD

The present PhD is part of the LabCom (joint laboratory) ANR "Perf-ISI/ Performance in Fire Safety Engineering" which associates the Heterogeneous Combustion team of the Pprime Institute (UPR 3346 CNRS) and Efectis France.

The Heterogeneous Combustion team of the Pprime Institute (UPR 3346 CNRS) – University of Poitiers – ISAE-ENSMA, located in Poitiers, has been developing for several years a recognized experimental and numerical expertise in the field of fire safety. Works concerning different applications, such as construction and housing, industrial and transport.

Efectis France is the largest laboratory in France in terms of fire resistance tests (evaluation of the fire performance of products, systems or structures), and fire safety engineering. Within Efectis France, the Research and Innovation Department allows the realization of development studies for its customers, in order to support them in their fire problems. This department is also involved in the training process, through the supervision of many engineering internships and PhD in connection with the universities and school of the fire community..

2. Context of the Joint Laboratory

Recent regulatory developments lead to a strong development of Fire Safety Engineering studies in France, which rely, in their performantielle approach, on the use of numerical models for the simulation of the development and fire behaviour of new structures and innovative materials. In parallel, following the recent accident at the Lubrizol plant (2019), the legislator imposed on facilities classified for environmental protection (ICPE) to report the gaseous emissions that would generate a disaster. The demands and needs are thus very substantial in different sectors of activity (construction, transport, industrial activity, etc.), while the scientific obstacles remain very important and multidisciplinary.

In this context, the PERF-ISI LabCom has a dual purpose:

- Improve the use and faculty of the calculation codes used for ISI studies to better describe the reaction processes to fire of materials (thermal decomposition, ignition, flame spread, extinction, effluents emitted) in the case of increasingly complex geometries and assemblies, which may incorporate bio-based materials, batteries or photovoltaic panels.
- Develop and validate an experimental protocol for the quantification of gaseous emissions representative of the reality of disasters, then improve the ability of models to describe these emissions.

3. PhD description

Depending on the challenges of the security study and the size of the sets to be modeled, different more or less complex numerical models are implemented during the ISI studies. The Fire Dynamics Simulator (FDS) calculation code is most commonly used for these studies. It has allowed over its

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various evolutions, to describe with more and more precision the aeraulic phenomena, fire development, heat transfer, etc. However, the simulation of phenomena related to chemical kinetics remains rather sketchy and can be used to account for the reaction to fire of specific materials (kinetics of thermal decomposition (pyrolysis model), ignition, flame spread, gaseous emissions, etc.). Thus, an important current scientific lock remains the description of processes in solid phase and gas phase, as well as their couplings, and phenomena at the interfaces.

In this context the objective of the PhD is to improve the FDS code so that it can better describe the reaction processes to fire that take place. This work is then based on experimental tests at different scales of work, then correlated, to the development and validation of the numerical code:

- To determine experimentally the thermo-physical properties of the solid materials studied and necessary as input data of the numerical models.
  Identification of the data required for the numerical models for the planned calculation code (SDS), quantification of the number of parameters and the intended operating range (combustion, pyrolysis).
  Determination within Pprime in thermogravimetric analyzer (TGA), in differential scanning calorimetry (DSC) and in cone calorimeter, of the thermo-physical properties of the studied materials: thermal conductivity, specific heat and density (k, ρ, Cp), reaction enthalpies and kinetic parameters from mass loss, mass loss rate, temperature and energy data.
- Experimentally characterize thermal decomposition, ignition and flame propagation processes, identify key processes.
  From small and medium scale tests, the processes of thermal decomposition (loss of mass, rate of mass loss and temperature in the solid) and combustion (ignition time, rate of heat release, temperatures in the gases) are characterized for different experimental conditions implemented. On a larger scale, in radiant panel (Pprime), the processes of ignition and flame propagation are studied, whether they are co-current or counter-current, vertical or horizontal. This analysis is complemented by large-scale tests conducted at Efectis' facilities.
- Develop numerical models to improve prediction capability.
  From the previous phases, pyrolysis models are developed and validated on an increasing scale, by comparison of experimental and numerical results: determination and optimization of kinetic mechanisms, verification and validation of design codes by material and scale. Once the pyrolysis model is validated at all scales, it is used by the partners to better describe the flame propagation processes, with an optimization of the description of heat transfers, flame/wall interaction, combustion kinetics, etc. The digital simulation expertise of both partners is thus mobilized.

The PhD student will also be associated with all LabCom's work. He or she will participate in the various meetings of the consortium as well as the meetings of the LabCom scientific council. Finally, a contribution to the scientific valorization of the results is expected from the scientific community (publications, symposia, etc.) as well as society.

4. Administrative part

Place: The PhD will take place at the Pprime Institute (UPR3346 CNRS-University of Poitiers, ISAE-ENSMA), on the Futuroscope site, in Chasseneuil du Poitou.

Recruitment period: 36 months from 1 March 2024

Diplomas: Master or Engineer in Science

Skills: It is desired that the doctoral student possess strong scientific skills in the scientific fields encountered during combustion and fire processes: heat transfer, aeraulic, thermodynamic, chemical kinetics.

Skills in the field of combustion and fire safety are very important.

It is required to know how to work independently and in a team, to have analytical skills and to be a force of proposals. Finally, the ability to write and present in English is expected.

Application: CV + cover letter at Thomas Rogaume, University of Poitiers, Institut Pprime. thomas.rogaume@univ-poitiers.fr and Virginie Dréan, Efectis France. virginie.drean@efectis.com

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