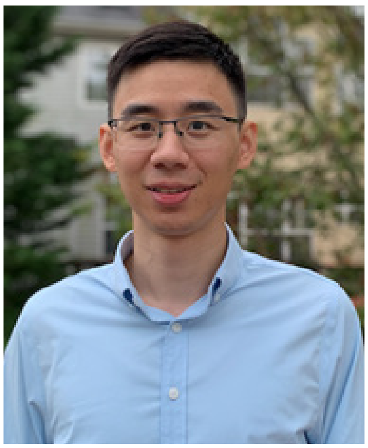
UNIVERSITY OF MARYLAND

THE BURGERS PROGRAM FOR FLUID DYNAMICS
THE FLUID DYNAMICS REVIEWS SEMINAR SERIES

A FLAMELET APPROACH FOR LARGE EDDY SIMULATIONS OF COUPLED COMBUSTION AND RADIATION IN TURBULENT BUOYANT DIFFUSION FLAMES



Friday, October 29, 2021 | 11am

DeWalt Seminar Room
2164 Glenn L. Martin Hall

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ABSTRACT

In traditional computational fluid dynamics (CFD) descriptions of fires, the combustion and radiation models generally rely on a global combustion equation and the assumption of a linear relationship between radiative power and heat release rate. These models may lead to a crude treatment of important phenomena such as flame extinction, formation of soot and toxic species, and the change of radiant emissions in response to evolving fire conditions.

The general objective of this Ph.D. study is to evaluate the potential of advanced combustion and radiation models for large eddy simulations (LES) of fires. A flamelet-based modeling framework is proposed that considers established or modified steady and unsteady flamelet formulations. This study is part of an international collaborative project between the University of Maryland and the University of Poitiers (France) aimed at providing a fundamental understanding of coupled combustion-radiation phenomena in fires. It consists of two parts.

The objective of the first part is to bring fundamental information on the coupling between combustion and thermal radiation occurring in laminar flames. The analysis demonstrates that for conditions far from the extinction limits, the flame belongs to the semi-unsteady regime in which mixing processes occurring in the outer diffusive layers of the flame are unsteady whereas heat release processes occurring in the inner reactive layer remain quasi-steady.

The objective of the second part is to develop and validate a fully coupled flow-flame-radiation fire modeling framework. A novel unsteady flamelet model is developed that includes: detailed information on combustion chemistry through a tabulated chemistry approach; a careful description of the combustion-radiation coupling; a description of subgrid-scale turbulence-radiation interactions; and a description of non-grey radiation effects through a Weighted-Sum-of-Grey-Gases (WSGG) model. This new combustion/radiation model is then incorporated into the LES solver FireFOAM (developed by FM Global) and is evaluated by comparisons with experimental data obtained in a turbulent line burner experiment previously studied at the University of Maryland. Comparisons between simulated and measured temperatures show relatively good agreement and significant improvements compared to a previous model based on the steady flamelet approach. In addition, comparisons between simulated and measured values of the global radiant fraction show that provided that the WSGG option is used, the flamelet model is capable of simulating changes in the flame radiative emissions that result from changes in the oxygen strength of the coflow.

BIO

Rui Xu is a Ph.D. student in Mechanical Engineering under the supervision of Professor Arnaud Trouvé at the Department of Fire Protection Engineering, University of Maryland. His research interests include computational fluid dynamics, fire modeling with large eddy simulation, simulation of thermal radiation transport phenomena, turbulence-chemistry interactions, and turbulence-radiation interactions. In particular, he works on developing advanced combustion and radiation models for CFD fire modeling.

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