Industrial Fire Suppression: development, validation, and application of FireFOAM

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The fire research community has recognized a need to predict fire-growth behavior and fire-suppression phenomena within the framework of physics-based models. Such modeling capability—in the form of CFD tools that allow for the full simulation of relevant physics—has greatly enhanced the ability to provide insight and guidance for fire-protection requirements.

With the goal of developing advanced CFD fire modeling capabilities for large-scale industrial fires, FM Global has established an extensive research program, combining experimental and numerical efforts, in the areas of fire growth, material flammability, and fire suppression. As a part of these efforts, FM Global, in collaboration with academia and industry, has facilitated the development and integration a number of key physical models relating to fluid mechanics, heat transfer, combustion, and multiphase flows into an OpenFOAM-based solver, FireFOAM. In addition, several other non-fire related aspects have stemmed from this work, namely the arbitrary mesh interface (AMI) and the Adaptable IO System (ADIOS) integration with OpenFOAM.

A major component of this effort has been model verification and validation. Key physics of the model that have undergone extensive validation are turbulence, buoyancy, non-premixed combustion, solid pyrolysis, convective/radiative heat transfer, thin-film flow, and spray transport. Additionally, new models are under development to capture gas-phase extinction, and radiation attenuation due to spray. Lastly, volume of fluid (VOF) modeling is underway to simulate primary atomization of sprinklers.

Finally, modeling has been applied to simulate practical fire-suppression scenarios and to guide testing. Several examples of successful application of FireFOAM to solve real-world problems include in-rack sprinklers, roll-paper fire protection, and sloped ceilings. Examples of each will be shown.