FireFOAM Modeling of Water Mist for Suppression of Compartment Fires

N. Ren*, H.Z. Yu, K.V. Meredith and Y. Wang

Research Division, FM Global, 1151 Boston-Providence Turnpike, Norwood, MA, 02062

Abstract:

Direct flame quenching is one of the key fire suppression mechanisms for water mist fire. The small droplets of water mist spray evaporate quickly in a fire environment and produce a large amount of water vapor. In this process, the spray evaporation cools the flame and the generated water vapor dilutes the local oxygen. These two effects change the energy balance between local heat release rate and heat loss rate, which may lead to a local flame extinction event. The local extinction event can be described by the Damköhler number concept. In this study, a flame extinction model is developed based on the Damköhler number concept, in which flame extinction is determined by the flame temperature and turbulent flow strain rate following a flammability map. Simulations are conducted for 1) a bench-scale Wolfhard-Parker slot burner and 2) a large-scale enclosure fire. The bench-scale study is targeted to evaluate the accuracy of the extinction model in an inerting environment without the presence of water mist. The large-scale enclosure configuration provides a realistic water-mist fire-suppression scenario to understand the model performance in practical applications. In the bench-scale study, the model shows good agreement with the measurements for both combustion efficiency and flame height. In the large-scale study, the model shows the same trend in predicting the suppression effectiveness for 156 kW and 686 kW fires. In addition to the effects of spray cooling and oxygen depletion by water vapor, the spray induced flow bringing the oxygen-lean smoke into the flame is also a very important mechanism for compartment fire suppression.

Keyword: FireFOAM, water mist, fire suppression modeling, compartment fire