LARGE-SCALE UNCERTAINTY/SENSITIVITY SIMULATIONS OF COMPLEX SYSTEM RESPONSE IN FIRE ENVIRONMENTS

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Characterization of a complex engineered system's thermal response to fires must depend on modeling and simulation to complement physical experiments which can be very expensive. Simulations that computationally resolve both the fire physics and the object response phenomena simultaneously in a fully coupled calculation are presently too large to be run in a production mode for large uncertainty/sensitivity studies -even with today's massively parallel computers. Therefore, the calculations must be decoupled and run separately, with appropriate information transfer between the two calculations. Even within just the object response calculation, careful decoupling must sometimes be implemented between system-level and detailed component-level thermal response calculations. This multiscale modeling approach extends down to the phenomenological and constitutive modeling levels where information from fundamental discovery and characterization experiments is brought into the model in some useful (often aggregated, conditional, transformed) form consistent with the formulation and purpose of the system analysis.

In this talk we describe several instances where constitutive, component, and subsystem experimental data and associated uncertainty are folded into a system-level model for predicting component failure in a complex object heated by fire. Specifically, five modeling elements and their uncertainties are examined: 1) fire modeling/ simulation for calculating the heating boundary conditions on the object; 2) heat transport properties of various materials in the object and its components; 3) a constitutive model for thermal-chemical pyrolysis and vaporization/recession of a component packaging material (foam); 4) the component's thermal failure threshold (correlation between its thermal state and when it fails); and 5) numerical/discretization effects due to time, space, and process discretizations in the calculations. For many of these modeling elements both alleatoric variabilities and epistemic uncertainties exist. Affiliated techniques used for uncertainty characterization, propagation, and assessment in an uncertainty/sensitivity analysis will be discussed. The various subcomputations and their interfacing/coupling will also be discussed, along with lessons learned and experiences gained in this activity. Some results of a sensitivity study to rank the importance of the various physical, modeling, and numerical uncertainties with regard to particular measures of system response will be presented.

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