Mechanism of Burning of Charring Polymers

Stanislav I. Stoliarov[a], Sean Crowley[b], Richard N. Walters[b], and Richard E. Lyon[b]
[a] Department of Fire Protection Engineering, University of Maryland, College Park, MD 20742
[b] Federal Aviation Administration, Airport and Aircraft Safety Research and Development Division, W. J. Hughes Technical Center, Atlantic City International Airport, NJ 08405

ABSTRACT

It is recognized that the processes that take place in the condensed phase of a burning polymer play an important role in the overall combustion. Quantitative understanding of these processes is critical for prediction of ignition and growth of fires. In the current study, a model of burning of two widely-used charring and intumescing polymers, bisphenol A polycarbonate (PC) and poly(vinyl chloride) (PVC), was developed and validated. The modeling was performed using a flexible computational framework called ThermaKin. ThermaKin solves time-resolved energy and mass conservation equations describing a one-dimensional material object subjected to external heat. Most of the model parameters were obtained from the results of direct property measurements, which is the key distinguishing aspect of this work. The model was employed to simulate cone calorimetry experiments performed under a broad range of conditions. Various ways to represent PC and PVC intumescent chars within the model framework were examined. An approach where the decomposition kinetics, which was measured using a thermogravimetric analysis, defines the expansion was adopted. The simulation results indicate that the cone calorimetry tests can be predicted equally well by assuming either conductive or radiative heat transfer inside the chars. However, the derived conductivity values, 3.7 W m^{-1} K^{-1} for PC and 1.8 W m^{-1} K^{-1} for PVC, appear to be too high to be consistent with the char structures, which contain at least 85 vol.% of gas-filled void. Therefore, it was concluded that the radiative char submodel, where the heat flow is described by the radiative diffusion approximation, provides a more consistent description of these chars.