EXPERIMENTAL AND NUMERICAL STUDIES OF THE EFFECT OF WATER MIST ON PREMIXED GAS AND SOLID FUEL FLAMES UNDER VARIOUS BURNING CONDITIONS

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Several investigations of the efficacy of water mist as a fire suppression agent are being conducted at the Colorado School of Mines. Fundamental interactions between premixed propane/air flames and water mist have been studied experimentally and numerically under normal and reduced gravity conditions in order to better understand the relative importance of various suppression mechanisms for a given set of burning conditions. We are also currently performing full-scale experiments and numerical simulations to study the effect of fine water mist in suppressing thermoplastic fires in electric/electronic applications. This latter work is intended to explore the practical application of fine water mist as a fire suppression agent for enclosed electrical/electronic cabinets.

Computer modeling of premixed flames has shown that the burning velocity decreases with increasing water-to-gas ratio and smaller water droplets are generally more efficient in fire suppression. A "turning point" in the burning velocity as a function of water loading has been observed and attributed to the residence time of the droplets in the flame zone. Approximately 80% of the mist suppression effects are shown to be related to thermal and physical mechanisms, leaving 20% of the suppression effects due to chemical and third body effects. Modeling of the absorption of radiation by water mist droplets shows an increase in the evaporation rates of the droplets, which affects the unburned gas composition and temperature. The radiation shielding suppression mechanism is found to be more strongly dependent on mist loading than on droplet size.

The ongoing full-scale laboratory tests and simulations for electrical/electronic cabinets are evolving from relatively simple, low fidelity configurations and very large parameter space to more realistic arrangements with reduced parameter space. Initially, tests are being performed with and without ventilation on single, vertically oriented thin sheets of poly methylmethacrylate (PMMA) ignited along the bottom edge. Preliminary results show that the average mass loss rate (change in mass/total burning time) is: 1) reduced significantly in the presence of mist, and 2) initially increases with burning time then decreases as the local oxygen concentration is depleted. In the ventilated case, direct contact with the mist jet is required to extinguish the flame. This experimentation is being expanded to include a "card rack" arrangement with the test article surrounded by nonflammable obstructions and, finally, an enclosure will be included to simulate an electronics cabinet. In conjunction with the experimental results, the FDS fire simulation code developed at NIST will be used to determine the contributions to fire suppression of thermal cooling, radiation, and oxygen dilution in order to optimize the nozzle spray characteristics, placement, and identify the key design parameters.