

## Some Difficult Problems in the Modeling of Fire Spread

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A fire and the objects involved in the fire form a highly complex dynamic system. Important processes occur over a wide range of spatial and temporal scales, from the microscales of thermodynamics and chemical kinetics, through the mesoscales of heat transport, bubbling behavior, and flow, to the macroscales of room flashover and forest fires. Processes of primary importance in the spread of fire may include ignition, chemical degradation, charring, suppression, heat transfer, and radiation. The geometry of burning objects is a critical factor.

Objects made of thermoplastic polymers, including foams used in chairs and mattresses, thin, solid sheets used in electronics housings and vinyl house siding, as well as fibers used in many carpets and fabrics, form a large and growing component of the fire load in buildings. These materials melt at elevated temperatures, making them easy to manufacture into complex molded parts. A wide variety of chemical formulations and additives provides tremendous flexibility during the manufacturing process and in the final product. However, the same property that imparts major benefits during manufacturing also adds significant complexity to the behavior of a fire, as thermoplastic objects melt and flow in high temperature environments. Large changes in the shape of burning objects have large effects on the spread and growth of fire. Fire tests performed on thermoplastic materials demonstrate some of these complex behaviors and the often surprising effects of changes in formulation and additives. To better predict fire behavior, we need a better understanding of how these materials burn.

Although significant progress has been made in computational modeling of fire spread, these models are based on empirical determination of the rate of heat release from ignited objects, usually obtained from small- or medium-scale fire testing. The standard finite difference and finite element techniques are limited in their ability to simulate the large changes in shape that accompany the burning of thermoplastic objects. A breakthrough in numerical modeling techniques is needed. Might meshfree methods provide the next jump in modeling capability?