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Evaluating Ignition Criteria for Cellulosic and Synthetic Polymers Under Extreme Irradiation

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Abstract

Flaming ignition of a heated, pyrolyzing solid is a complex gas-phase event dependent on interactions between the solid, the gas, and the heat source. Historical data for cellulosic materials under extreme irradiation (>>100 kW/m^2) indicate the ignition problem can be dominated by heat-transport phenomena in the solid-phase. Under this regime, ignition depends solely on the properties of the solid and the dynamic profile of the heat source, simplifying ignition predictions considerably. Experiments with Sandia's Solar Furnace as a radiant heat source (up to 6 MW/m^2) evaluated the magnitude of ignition thresholds and the suitability of these ignition criteria for a variety of polymeric materials, heating conditions, and geometries. While the model consistently predicts ignition for cellulosic materials, many polymers are less consistent and exhibit phenomena poorly captured by simple solid-phase ignition models. We identify sample properties that define suitability of solid-phase ignition models, including: char formation, scale, optical properties, and decomposition. The results of this study guide the application of solid-phase ignition models commonly used in extreme heat flux scenarios.

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