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Shock Ignition of Particles

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6.1 Introduction

Ignition and combustion of fine solid particles and liquid fuel drops ("particles," for short) are important issues for various branches of science and technology, such as aerospace and chemical technologies, chemical propulsion, ground transportation, and industrial safety. These issues were noticed by numerous researchers both at the end of the foregoing century and presently, and many relevant publications are available. Detailed reviews of the current status of the research can be found elsewhere [1–5].

Particle ignition and combustion are phenomena comprising all the main constituents of the combustion process; namely, fast exothermic chemical reactions complicated by diffusion of reactants and products, thermal energy deposition and spreading of heat in the medium, and convective flows. The classical theory implies that particle combustion is diffusion-limited and therefore chemical kinetic aspects are usually not considered in the analysis [6–15]. In addition, the classical theory considers an isolated particle in an unconfined state. Within these presumptions, notable progress in understanding relevant physical and chemical processes has been achieved recently. However, for problems dealing with transient modes of combustion, such as ignition or extinction, it is necessary to consider the effects of finite-rate chemical kinetics. Moreover, in practice, particle ignition and combustion occur in the presence of neighboring particles or confinement surfaces. The corresponding effects are usually referred to as "spray" (or "collective") and "confinement" effects.

Spray effects manifest themselves in two-phase reactive flows. In existing computational approaches, chemical reaction rates are determined by considering particles as distributed mass, momentum, and energy sources. As a matter of fact, spray ignition and combustion phenomena are a complex combination of chemical kinetics and diffusion-controlled flames around individual particles, their groups, and gas-phase partially premixed flames.

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