

FOREWORD

Method is needed to find the truth.
Rene Descartes

Regimes and parameters of combustion of condensed systems (CS) are governed by the properties of their components and by thermodynamics, physical chemistry, heat and mass transfer laws [1]. However, in the available literature on theory of CS combustion, only little attention is paid to the kinetics of phase transformations. Peculiarities of these transformations were neglected in the calculations. The present author intends to fill this and other existing gaps, essentially by his publications.

The presence of a phase interface is a specific feature of the CS burning process, which makes a basic difference between CS burning and combustion of gaseous mixtures. Intermitted and jumpwise nature of phase and chemical transformations, as follows from the equation of state of CS (the entropy increment $\Delta S \neq 0$, and volume increment $\Delta V \neq 0$), precludes homogeneous behavior of the process throughout the material mass [2].

Quasi-instantaneous (jumpwise) increase in the material volume as its temperature rises is a physical ground for and creates prerequisites for

- microexplosions at the nucleation stage;
- explosion-like crystallization, cavitation, noise generated by water being heated before its boiling volcanic ashes formation, exploding wires, etc.;
- macroexplosions of large amounts of material preheated above the temperature at which its conversion starts.

Heterogeneous reaction and evaporation start in microscopic nuclei of the new phase. The vaporizing components and products of their thermal decomposition (thermolysis) fill the micronucleus volume in which no individual reaction or vapor nuclei reside. Only common vapor-reaction nuclei are formed that are filled both with vapor and reaction products.

Description of such nucleation kinetics in thermally unstable media is beyond the frames of classical Volmer–Doering–Frenkel theory of phase transformations.

The common concurrent reaction and phase transformation process is conditionally termed chemophase transformation (CPT). The author is the first, as shown in the book, to introduce CPT rates and parameters and the temperature of superheating attained in the set of governing equations of mathematical CS burning models.

It is shown both theoretically and experimentally that kinetic CPT characteristics at low (LT) and high temperatures (HT) (exceeding the temperature of phase transformation beginning) differ significantly.

The present book is aimed at familiarization of a reader with newly-found peculiarities of fast HT phase transformations and CPT, including spontaneous boiling and sublimation, the effect of which on CS burning regimes is not less significant than that of chemical reactions. Method & Techniques suggested by the author for their determination and mathematical modeling are described. Explosion is regarded for the first time as a consequence of propagation of a thermal superheat wave in CS. The thermal wave spreading at a near-sonic velocity gives rise to a shock wave that accompanies expansion of the gaseous thermolysis reaction products. Materials from commonly accessible scientific publications appeared mostly during the past twenty years are included in the book.

The limited size of the publication has not permitted the author to discuss CS detonation and processes and combustion of gaseous CS decomposition products that are described by the gasdynamic and chemical kinetics equations. Interaction of gases with the condensed phase surface remained also beyond the scope of the book. Therefore, the term “materials” indicated in the book title is to be considered as an abbreviation of the term “condensed (i. e., nongaseous) systems” CS, such as components of rocket propellants, gun powders, and explosive and pyrotechnic mixtures.

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Author