PREFACE TO THE ENGLISH EDITION

This book offers a new concept of combustion and explosion kinetics.

The new method of contact flash thermal analysis (FTA) and an apparatus designed for carring out such an analysis have been developed for studying the combustion kinetics of energetic materials (explosives, propellants, and pyrotechnic composition). The FTA method makes it possible to obtain hitherto unknown kinetic characteristics of high-temperature decomposition near the combustion surface of the condensed phase with the help of rates of heating up to 10^6 K/s. These characteristics substantially differ from those obtained by thermal gravimetric analysis (TGA), differential thermal analysis (DTA), and other standard methods at lower temperatures with heating rates of 2–50 K/min. At these low rates of heating, the samples disintegrate before the surface high combustion temperature is reached.

The FTA method also made it possible for the first time to determine the attainable superheating temperatures of many energetic materials. A table setting out the theoretical combustion parameters and experimentally attainable superheating temperatures is presented for a series of energetic materials. These temperature are established on combustion surface of explosives at high-speed burning (0.5–1.5 km/s), i. e., subdetonation (e. g., smoke powder).

As shown by an analysis of the thermolysis products and flash calorimetric measurements, the difference in characteristics is due to an increase in the frequency rate of nanonucleation under superheating condition, that is, above the temperature when phase transformation begins.

In standard TGA and DTA measurements and combustion modeling, the chemical and physical transformations are to be considered as the separate processes. In the case of superheating during combustion/ explosion, these processes are a single autocatalitic chemophase transformation (CPT) with its own united parameters: energy activation of

CPT, frequency factor of CPT, reaction order of CPT, free energy of nucleus formation, etc. The existing modeling methods based on standard TGA and DTA yield results which do not appropriately correspond the experimental combustion data for rocket propellants. Taking into account superheating and subsequent CPT in condensed systems, the calculated combustion parameters come close to the actual values.

The onset of the explosion of energetic materials is found to be due to wave propagation approaching sound velocity of the overheating impulse and to the accompanying CPT. The initiation of combustion by impact is caused by the mechanoactivation of nanonuclei following their deformation.

The new FTA method eliminates shortcomings of the existing way of extrapolating results and is applicable to modeling the behavior of new compositional propellants and explosives during deflagration and subdetonation. Both the method treatment and the modeling are based on new conception of combustion derived from governing CPT, mechanoactivation, and differential heat conductivity equation of the parabolic and hyperbolic wave types with respect to overheating attainable temperatures.

The CPT characterizes not only explosion of energetic materials and deflagration of rocket propellants but also chemicotechnological processes involving gas formation such as the cracking of heavy oil fractions, plasma chemistry, polycondensation, etc.

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