Features of the physicochemical mechanism of reactions of combustion, explosion and detonation of gases, development of chemical methods of process control

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The increased interest in the processes of combustion, explosion and detonation of gases is determined by their strategic role in technology, energy and everyday life. The specificity of the reactions underlying these processes is as well one of the topical problems of the theories of chemical kinetics and combustion. At the same time, the fundamental problems of the chemical and physicochemical aspects of these phenomena began to be solved only in the last three decades. It was generally accepted that combustion during self-heating was caused only by heat release. The role of reaction chains was ignored and denied even in fundamental monographs and encyclopedias. Using a hypothetical model of a one-stage reaction, it was only possible to formally describe the reaction kinetics under conditions corresponding to the accepted calculation parameters. However, in the works of the Russian Academy of Sciences with the participation of the Ministry of Emergency Situations it was shown that the generally accepted one-stage model contradicts the fact that the combustion, explosion, and detonation of gases occur. It was found that in all combustion modes the reactions are solely chain reactions. The laws of these non-isothermal chain reactions that determine the course of these processes are revealed. It has been established that even in a laminar flame, the characteristic reaction time is less than 10^{-4} s. In detonation, this time is less than 10^{-6}s. Extremely high velocities and accelerations are determined by the previously unknown law of the temperature dependence of the chain reaction rates, which is expressed as an exponent that contains in its positive exponent the Boltzmann factor with the activation energy of the limiting stage. The law of "exponent in a positive exponent" also determines the multiplication of free atoms and radicals during combustion and explosion. The concentrations of active particles in the flame exceed the equilibrium values by many orders of magnitude due to the conversion of most of the reaction enthalpy into the energy of free valences of atoms and radicals.

Examples of the application of the developed chemical methods for controlling all the characteristics of combustion, explosion and detonation of gases are given. The methods also use the resonance of intramolecular vibrations of the additive and the intermediate particle. A strong effect of heterogeneous reactions of atoms and radicals on flame propagation and explosion was revealed. It is shown that the taking into account these reactions is necessary condition for the reliability of mathematical modeling of combustion.