SPONTANEOUS APPEARANCE OF DETONATION REGIME AT SELF-IGNITION OF A GASEOUS MIXTURE: ANALYSIS OF REGULARITIES

O. V. Sharypov

Institute of Thermophysics, Siberian Branch of Russian Academy of Sciences,
Lavrentyev av., Novosibirsk, 630090, Russia
e-mail: sharypov@itp.nsc.ru

The great contribution to the problem of detonations was made by R.I. Soloukhin. A number of his original works opened new directions for research. Among them is the problem of detonation generation [1, 2]. Soloukhin's understanding of this process as an "explosion inside explosion" [3] is a very fruitful idea that is being developed and used for explanation of a wide range of phenomena.

The model of spontaneous appearance of a detonation regime of a distributed exothermic chemical reaction in a gaseous mixture is presented. An explanation of the physical mechanism of this phenomenon is based on the concept of collective effects under non-linear wave-kinetic interaction in reacting systems with fluctuations. Dynamics of the spontaneous process in a reacting system is described, assuming uniform macroscopic initial conditions with weak “noise” (uniform in all spectrum of permissible frequencies). Such a statement of the problem allows the study of general regularities of the phenomenon (and the “gradient” mechanism of detonation appearance becomes a special case of spontaneous evolution of a reacting system). To describe the generation of spontaneous detonation process in a system at the threshold of self-ignition the earlier obtained results of analysis of evolution of plane disturbances of small but finite amplitude in reacting media are used in the work. In contrast to the last results the new model describes the evolution of weak stochastic initial plane disturbances propagating in both directions. Due to this the model takes into account the effect of wave collisions, which is of great importance for generation of zones with an extremely high reaction rate. Relative simplicity of the created model allows one to predict a qualitative scenario of dynamics of a preheated reacting system at the threshold of self-ignition. The model makes it possible to substantiate quantitative criteria of spontaneous deviation of the system from the uniform explosion regime. They consist in the following: a) the chemical reaction is far enough from equilibrium, and weak long-wavelength disturbances increase with time); b) the size of the system exceeds the wavelength of neutrally stable disturbance. The developed approach logically joins the opposite concepts of the spontaneous explosion process description: a deterministic approach at the stage of macroscopic non-uniformity development is complemented by a probabilistic one due to the use of stochastic infinitesimal disturbances of the initial state of the system.

References

[1] Soloukhin R.I. (1961) Deflagration to Detonation Transition in Gases. Priklad. Mekhanika i Tekhnich. Fizika, Iss. 4, P. 128-132.
[2] Soloukhin R.I. (1963) Detonation Waves in Gases. Uspekhi Fizich. Nauk, Vol. 80, Iss. 4, P. 525-551.
[3] Oppenheim A.K., Soloukhin R.I. (1973) Experiments in Gasdynamics of Explosions. Ann. Rev. Fluid Mech., Vol. 5, P. 31-58.