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ABSTRACTS

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INITIATION OF A DETONATION WAVE DUE TO MULTISTAGE SELFIGNITION

Frolov S.M., Gelfand B.E., Machviladze G.M., and Tsyganov S.A.
Institute of Chemical Physics, USSR Academy of Sciences
Kosygyin str., 4, Moscow 117977, USSR

The paper deals with the theory of 'knock' phenomenon in internal combustion engines. The fruitfull suggestions by Sokolik on considerable effect of low-temperature multistage selfignition of hydrocarbons on shock wave formation in engines as well as a fundamental idea by Zel'dovich on a possibility of shockless detonation initiation in conditions close to reactive mixture selfignition are taken as a basis of the present theoretical approach. We consider a finite volume of fuel-air mixture placed into a medium with lower chemical activity and simulate two-stage chemical release in it by two distinct kinetic equations of the Arrhenius type describing 'cold flame' and 'hot' explosion stages of the process. The Euler equations for unsteady flow of combustible gas are integrated numerically in order to reveal the hystory of events in initially quiescent and homobaric system. Three principal parametric domains are identified, namely, 'cold', 'hot', and 'shock'. The first contains only a 'cold flame' explosion due to a rarefaction wave quenching effect accompanying thermal explosion of the volume. In the second domain chemical energy is released like in a single-stage thermal explosion without any noticeable interaction with gasdynamical flowfield. Within the third, 'shock', domain there is a vigorous chemical - gasdynamical coupling resulting in shock or even detonation formation inside the volume. In the instance a rarefaction wave propagates through the volume after the first stage of reaction thus producing conditions for rapid amplification of a pressure wave generated by subcequent 'hot' stage of explosion. A detailed study of amplification mechanism is undertaken. Boundaries of 'shock' domain are found analytically on the base of Zel'dovich classification of chemical wave propagation regimes. A simple coupling criterion is proposed and a good quantitative agreement is shown to exist between this and numerical calculations. Qualitatively, the criterion appears to account for numerous features of 'knock' phenomenon.