GRADIENT MECHANISM OF DETONATION INITIATION UNDER ACTION OF HIGH-VOLTAGE NANOSECOND DISCHARGE

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Studies of different mechanisms of detonation initiation in combustible gaseous mixtures are related to the necessity of development an ignition device for application in pulsed detonation engines (PDE). The application requires a robust energy–efficient methodof initiation Chapman–Jouguet (CJ) detonations in tubes within distances of several calibers and times of ~1 ms. The most common approach is deflagration to detonation transition (DDT) facilitation by the application of various types of obstacles that turbulize the flow and increase the flame velocity, which was initially suggested by Shchelkin [1]. Alternatively, the concept of detonation initiation through a gradient mechanism was theoretically introduced by Zeldovich [2]. This case was numerically studied in a series of papers reviewed in [3]. Various scenarios of hot spots formation due to shock–flame interaction and the role of their structure were also discussed in that paper. A similar concept of the shock–wave amplification by coherent energy release (SWACER) was introduced in [4], where this process was investigated in more detail. Pulsed nanosecond discharge in the form of a fast ionization wave (FIW) was proposed as a tool for detonation formation length and time reduction in [5].

An experimental study of detonation initiation by high–voltage nanosecond gas discharge has been performed in a smooth detonation tube with a four–cell discharge chamber designed to realize a gradient initiation mechanism. Stoichiometric propane–oxygen mixtures were used at initial pressures from 0.2 to 1 bar. Detonation was formed within 4 transverse tube sizes at initial pressures higher than 0.2 bar for the propane–oxygen mixture and higher than 0.8 bar for the diluted mixture with 40% of nitrogen. The discharge energy inputs were 0.2—0.3 J. The time of detonation formation was below 0.5 ms for all conditions. Combined with the focussing effect of the converging reducer, the gradient mechanism of detonation formation similar to the one suggested by Zeldovich has been shown to be the governing process. The value of the ignition delay time gradient, formed by non–uniform radical production during streamer discharge and following rapid plasma thermalization, has been estimated to be consistent with the condition on gradient mechanism realization.

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