DEFLAGRATION TO DETONATION TRANSITION IN TURBULENT GAS FLOW

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The quantitative prediction of the deflagration to detonation transition (DDT) in pulsed detonation devices (PDD) is one of the major unsolved problems in combustion and detonation theory. It is an extremely difficult and interesting scientific problem because of the complex nonlinear interactions among the different contributing physical processes, such as turbulence, vorticity, shock interactions and energy release. Reduction of the transition length is especially important in developing pulsed detonation devices that must be compact and efficient.

Most studies on DDT were made in initially quiescent combustible mixtures. There are many data on the DDT process in different mixtures, on the detonation velocity and predetonation distance and detonation limits. But all these data were obtained for the gas being initially at rest. The authors of the paper were the first who had found that the initial turbulent flow field in the detonation chamber may have a great influence on DDT [1]. A great reduction of the predetonation distance in methane-oxygen mixtures has been found. This experimental result was supported by the numerical investigation of the authors [2].

The results of further experimental and numerical investigations of the phenomenon are given in the present paper. Experiments are made in a special detonation tube with the valve that can simulate one cycle of an action of a pulsed detonation engine. Measurements are conducted using pressure gauges, ionization gauges, and photodiodes. The system of recording allows obtaining the x-t diagram of the DDT process. Numerical investigations are done at the Research Institute of Mechanics and Mathematics (RIMM) of al-Faraby Kazak National University, Kazakhstan. The predictions of the RIMM team are based on numerical solutions of non-steady averaged 2D Navier-Stokes (ANS) and/or space filtered 2D Navier-Stokes (FNS) set of the conservation equations for mass, momentum, individual species, and total energy. Due to the high computational cost FNS code is applied to the combustion zone only. The simulations are made for the same mixtures and initial conditions as in the experiments.

The data of numerical experimental studies on DDT in the turbulent gas flow are analyzed and the conclusions about the physical model of the process are given. The studies of the authors have shown a principally new way to control the detonation formation in pulsed detonation engines.

References

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