Experimental/Numerical Exploration of Deflagration-to-Detonation Transition in unconfined/semi-confined media

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1 WiPP Abstract

Most of previous studies on deflagration-to-detonation transition (DDT) have worked on confined systems: channels closed by surrounding rigid walls. It is also important to consider DDT in unconfined systems in relation to hazardous explosions in gas-leakage accidents and stellar explosive phenomena of type Ia supernovae. Owing to conventional understandings that the flame acceleration prior to the detonation onset requires the wall reflection of shock wave to enhance its compression and the boundary layer to enhance the turbulent propagation, it has been a general consensus that DDT is impossible in an unconfined system. Still, we lack previous efforts on unconfined DDT. Actually, there are a few experimental evidences that unconfined DDT was achieved [1,2]. To resolve this inconclusive issue, we are motivated to reproduce their experiments and to explore wider conditions including some semi-confined systems with obstacles. In this study, elevated-pressure mixtures of hydrogen-oxygen and acetylene-oxygen are tested in experiments. For the hydrogen-oxygen mixture, 2D-axisymmetric simulations are performed as well. Equivalence ratio is taken to be 0.5, 0.8, and 1. Initial pressure is varied between 2 – 10 atm. In the experiments and simulations reproducing [1, 2] where the success of DDT was achieved, no DDT is confirmed. The detailed reason for this discrepancy is not clear due to some lacking information on their experimental methods, but it is indicated that the difference in the ignition energy has some contribution: their ignition energy may be much larger than applied in our study. All the other unconfined conditions fail to observe DDT, whereas the semi-confined setup putting a 1mm-thick plate with a diameter > 15 mm succeeds in DDT for 2-atm stoichiometric acetylene-oxygen mixture. The success is an important step to pursue the unconfined DDT, including inhomogeneous media like dispersed particles and turbulence.

References

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[2] J. W. Pliickebaum, W. A. Strauss, and R. Edse, Oppenheim AK. (1966). Novel Insight into the detonation process. Acta Astronaut. 11: 391.