Shock and Adiabatic Compression Ignitions of Inhomogeneous Gas and Two-phase Flows

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Experimental modeling of energy release deposition and reaction behaviour associated with a problem of combustion and detonation initiation in reaction systems is important for theory and applications. At real conditions, the traditional assumption on homogeneous distribution of local flow parameters is never fulfilled. For this reasons mainly all combustion and detonations initiation events are local and dependent on specific features of primary hot spots formation, which predetermine subsequent propagation scenarios in reaction flows. In this sense the ability of reactive system to generate hot spots (or exited states) any ways determines the sensitivity to explosions. Several mechanisms can be responsible for hot spot formation in standard gasdynamic environment. These are the local velocity fluctuations across the flow field resulting in occurrence of stagnant zone with higher temperature and pressure, interaction of shock-compression waves each other, with boundaries and local flow gradients, local remote temperature and radical excitations, and the presence of ultrafine or catalytic particles in the flow with higher reactivity.

Several experimental means of hot spot formation and their influence on auto-ignitions of inhomogeneous gas and two-phase flow are considered here. We investigated the influence of 2D and 3D shock-wave collisions on auto-ignitions in hydrogen/propane/air mixtures behind reflected shock waves. Different collisions and, subsequently, reactive hot spots were produced at interaction of the incident shock wave (ISW) with wedge and conical walls. Induction times and auto-ignition modes of the mixture (strong, transient and weak) [1-3] were measured by means of pressure, ion current, emission observations and high-speed imaging. The results were compared with a reference data obtained behind normally reflected shock waves [4]. The kinetic consideration of necessity of hot spot formation for steady state detonation propagation are made on the basis of time-resolved induction and reaction time measurements.

Low-temperature auto-ignitions of hybrid particle/methane/hydrogen/air mixtures at conditions of rapid compression were also studied in RCM machine. It was found that at temperatures lower 1000 K methane and hydrogen ignitions occur only when some amount of reactive particles are presented in the test volume. It was shown that auto-ignition of ultrafine particles starts to be earlier and control subsequent initiation of gas phase combustion at lower temperatures. The results are compared with shock tube data obtained at the same temperature and pressures

And, finally, different scenarios of the deflagration to detonation transition (DDT) in stationary and turbulent reacting flow are considered. Dynamic gasdynamic peculiarities of a combustion-driven shock wave complex are measured. It is shown that transmissions of a shock wave followed by deflagration into a semi-confined area could essentially facilitate the following detonation re-ignition and reduce the sensitivity and requirement for driver tube mixtures. Such transmission could produce the successful detonation initiation in a large volume, at least, at five times lower initial pressure than for the classical direct detonation transmission case. Different local detonation initiation events are captured and visualized by different high-speed imaging techniques.

References

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