VISUALISATION OF AUTO-IGNITION IN RAPID COMPRESSION MACHINE

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ABSTRACT: As a result of interest in gas turbine syngas combustion, experimental and theoretical studies of hydrogen contenting mixtures oxidation kinetics under conditions relevant to industrial turbine mixing systems (T<1000 K, 10<P<30 atm) have received renewed importance. As it was firstly shown in the work of Voevodsky and Soloukhin in 1964 [1] in the H_2/O_2 mixtures at these conditions the "strong" ignition process changes on a "mild" ignition which lead to anomaly reduction of experimental ignition delay times measured in shock tube. Further, numerous investigations of hydrogen mild ignition have shown that the reaction originates sometime earlier than chemical induction time from spatially distributed exothermic initiating centers [2, 3] appeared due to different kind perturbations connected with the presence of contaminants, fluid dynamic effects and catalysis from particles or surface materials. It can lead to significant reductions of measured induction times in the mild ignition regime by as much as several orders of magnitude. In order to get deeper understanding and to develop correct experimental data interpretation in the present study high-speed digital imagine has been used to visualize auto-ignition phenomena in rapid compression machine (RCM). Experiments have been carried out in stoichiometric hydrogen-air mixtures at temperatures 900-1000 K and pressures 0.8 - 1.8 MPa. Ignition times were measured by OH radicals emission observations and by pressure measurements as the time difference between pressure peak at the end of compression stroke and the onset of pressure rise (5 % of maximal rise) caused by reactive mixture ignition. Measurements were compared with previously obtained shock tube data for the same mixture compounds and densities [4]. Good agreement was found but new RCM data has big scattering. Several tests were performed at high pressures (about 3 MPa) in order to compare with ignition data obtained in others RCM. The rather good correspondence was found in spite of all previous high pressure RCM data was obtained in argon diluted H2/O2 mixtures.

High-speed digital imaging has been used to investigate the possible effect of particles presented in reactive mixture on induction time. The tracks, probably produced by burning particles, were registered on images explosed during 300 μs. The same picture was found in the experimental run with non-reactive mixture (50% O2 and 50 % N2). The photomultiplier recorded a low intensity light in the test volume just after compression. Like in the experiments with reactive mixtures the delay time of the appearance of this light was measured. This value is not significantly differing from ignition delay times measured in reactive mixture. Thus, the ignition of ultrafine particles can explain a big scattering of experimental data. As the effect of suspended particles can't be completely excluded from experiment we can conclude that RCM data obtained under studied conditions needs for a careful analysis before application for homogenous chemical kinetic models validation and updating.

References

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