LES of Laser Initiation of Combustion of Gaseous Fuel-Air Mixture

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The laser initiation of combustible fuel-air mixture is tricky [1]. Strong laser pulse and hence a strong blast wave delay/inhibit the occurrence of a stable flame by removing the flammable mixture from the hot zone. A significant part of the absorbed energy by the fuel-air mixture or pure air from a strong laser pulse is lost via the blast wave which is generated shortly after cessation of the pulse. A very weak laser pulse is not able to create the air-breakdown. Perhaps, a moderately strong pulse is the right choice for the initiation of the combustion.

The location of the pulse with respect to the injector exit is also crucial. A Close proximity between the two along the spraying direction can sweep/convect the blast wave system (including the hot core) far downstream due to large velocity of the atomized spray at injector exit. In such case a favourable condition for flame establishment may not exist inside the combustion chamber. Too large a distance between the two may result in no ignition at all due to loss of heat from the hot core before the fuel-air vapour could arrive at it. A possible location could be just downstream of the fuel vapour formation zone. In the above it is assumed that the timing of the start of injection could be controlled electronically e.g. pulse jet injector.

The flow-field structure of the region behind the blast wave changes rapidly, starting from a simple radially outward velocity field to the region which contains a pair of counter rotating vortices initially and later the appearance of a third lobe surrounding the small hot core.

In order to understand the process of initiation of a stable flame from the hot core and fuel-air vapour mixture, LES is performed. The initial conditions for the LES are taken to be the flow field containing the counter rotating vortices and laser pulse induced turbulence within an ethyl alcohol-air mixture. The compressible Navier-Stokes equations along with species conservation equations are solved along with the basic Smagorinsky model for the eddy viscosity.

The numerical results would be complimented with in-house experimental observations of the Laser initiation of combustion. The facility consists of a vertical flow channel of hexagonal cross section, pulsed laser source of 50 mJ pulse energy, an electronically controllable air blast fuel atomizer, a co-flow air supply fitted with a honeycomb structure.

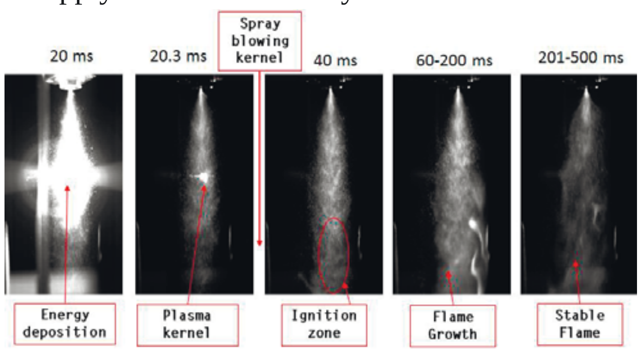

Figure 1; Experimental realization of laser initiation of combustion in ethyl alcohol-air mixture

[1] Awanish Pratap Singh, Upasana P. Padhi, Harikrishna Tummalapalli, Ratan Joarder, Investigations on Ignition of Atomized Fuel-Air Mixtures and Liquid Fuel Column-air Combinations by Low Energy Laser Pulses, 11th Asia-Pacific Conference on Combustion, The University of Sydney, NSW Australia 10th -14th December 2017.