ABSTRACT

Depleting fossil resources and increasingly stringent emission regulations motivate use of environmentally friendly and low emission fuel. Hydrogen is perhaps an ideal fuel in view of its ability to be generated from a host of renewable and non-renewable energy sources. Concerns about energy availability and pollutant emissions, such as oxides of nitrogen and particulates have driven concerted efforts towards the design of next generation internal combustion engines, capable of using such newer fuels, delivering higher efficiencies and lower emissions. Among various new engine designs and concepts, laser ignition is one such promising approach to attain these objectives.

Experiments were carried out in a constant volume combustion chamber (CVCC) to investigate the flame kernel development and flame speeds of hydrogen – air mixtures of various fuel – air ratios. A Q-switched Nd: YAG laser at 1064 nm wavelength with pulse duration of 6-9 ns was used for ignition by generating laser induced plasma inside the CVCC. In this study, laser induced ignition of hydrogen – air mixtures (fuel – air ratio; $\lambda = 1.5 – 8.0$) was investigated using different initial chamber filling pressures (P = 2.5 bar – 10 bar) and different laser pulse energies (10-59 – 17.15 mJ/pulse) at different initial CVCC temperatures (373K – 523K). A variable optical setup with different focal length converging lenses (f = 100 – 250mm) were used to position the plasma at various locations inside the combustion chamber. A high speed camera recorded the flame kernel development at 54000 fps and piezo-electric pressure transducer recorded the pressure – time history for all the experimental investigations. The results indicate that the phenomenon of micro-explosions in the wave-front of hydrogen-air mixtures lead to significantly different flame front evolution and higher flame speeds compared to methane-air mixtures. The objective of this investigation was to determine the dependency of combustion properties of laser ignited hydrogen – air mixture on laser, optical and initial conditions of CVCC.