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Characterization of Ethanol-Air Combustion in a Constant Volume Combustion Bomb Under Cellularity Conditions

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Abstract : In this work, an optical characterization of the ethanol-air laminar combustion is presented in order to investigate the origin of the instabilities developed during the combustion, the onset of the cellular structure and the laminar burning velocity. Experimental tests of ethanol-air have been developed in an optical cylindrical constant volume combustion bomb equipped with a Schlieren technique to record the flame development and the flame front surface wrinkling. With this procedure, it is possible to obtain the flame radius and characterize the time when the instabilities are visible through the cell's apparition and the cellular structure development. Ethanol is an aliphatic alcohol with interesting characteristics to be used as a fuel in Internal Combustion Engines and can be biologically synthesized from biomass. Laminar burning velocity is an important parameter used in simulations to obtain the turbulent flame speed, whereas the flame front structure and the instabilities developed during the combustion are important to understand the transition to turbulent combustion and characterize the increment in the flame propagation speed in premixed flames. The cellular structure is spontaneously generated by volume forces, diffusional-thermal and hydrodynamic instabilities. Many authors have studied the combustion of ethanol air and mixtures of ethanol with other fuels. However, there is a lack of works that investigate the instabilities and the development of a cellular structure in ethanol flames, a few works as characterized the ethanol-air combustion instabilities in spherical flames. In the present work, a parametrical study is made by varying the fuel/air equivalence ratio (0.8-1.4), initial pressure (0.15-0.3 MPa) and initial temperature (343-373K), using a design of experiments type I-optimal. In reach mixtures, it is possible to distinguish the cellular structure formed by the hydrodynamic effect and by from the thermo-diffusive. Results show that ethanol-air flames tend to stabilize as the equivalence ratio decreases in lean mixtures and develop a cellular structure with the increment of initial pressure and temperature.

Keywords : ethanol, instabilities, premixed combustion, schlieren technique, cellularity
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