Turbulent Flame Speed Of Spherical Flame In A Fan Stirred Closed Vessel

J. Goulier[1], N. Chaumeix[1], N. Meynet[2], and A. Bentaïb[2]
[1]CNRS - Institut de Combustion, Aérothermique, Réactivité et Environnement
Orléans, France
[2]Institut de Radioprotection et de Sureté Nucléaire,
Fontenay-aux-Roses, France

Recent benchmarks has shown the importance of the turbulent flame models used in the CFD codes used worldwide in the assessment of the explosion risk in nuclear power plants. In fact, the lessons learnt from these projects show that the computer codes are able to reproduce the pressure generated by combustion. On the other hand, they do not well predict the flame propagation regimes as observed in the experiments. These exercises highlighted the need to measure the turbulence in the fresh gases and to characterize the transition from laminar flame to turbulent flame regime. The aim of this paper is to report new experimental results on the effect of turbulence on the propagation speed of hydrogen/air flames to improve correlation between turbulent speed and turbulent integral scale.
To do so, a new experimental setup has been designed and built at CNRS-ICARE laboratory to investigate the effect of a given and well-characterized turbulence intensity on the increase of hydrogen/air flame speed. This new facility consists of a spherical vessel equipped (565 mm internal diameter) with 8 motors that can reach a rotation speed of 12 000 rpm. These engines are equipped with fans inside the bomb and when actuated can generate a turbulent flow inside the vessel prior to any ignition. The spherical bomb is equipped with 4 quartz windows (200 mm optical diameter) that allow the use of a PIV diagnostic in order to characterize the turbulence level inside the bomb.
These experiments were performed for lean to stoichiometric hydrogen/air mixtures from 16% to 28% of hydrogen fraction and for a rotation speed from 1000 to 5000 rpm. We were able to produce a large volume (around 100 mm in radius) inside the spherical vessel where the turbulence is indeed homogeneous and isotropic with intensities that varies from 0.57 m/s up to 3.79 m/s. Laminar and turbulent flame speeds of lean hydrogen-air mixtures at ambient temperature and pressure were measured using a high speed camera at 19 002 frames per second. A correlation between turbulent speed and turbulent integral scale is proposed and will be used to improve safety analysis of CFD codes predictions.

Correspondence to: nabiha.chaumeix@cnrs-orleans.fr