MEASUREMENT OF LAMINAR BURNING VELOCITIES OF FUEL-RICH METHANE-OXYGEN MIXTURES

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Introduction

The production of synthesis gas and higher hydrocarbons by turbulent combustion of premixed, fuel-rich methane oxygen mixtures is applied industrially since the 1950s [1]. In such a partial oxidation process only the necessary amount of methane is burnt to provide the energy for the pyrolysis of the remaining methane.

The laminar burning velocity is a key parameter describing the physicochemical interactions in combustion systems and is also used to model turbulent combustion, e.g. [2]. Experimentally determined laminar burning velocities of methane and pure oxygen mixtures were carried out by Jahn [3] in 1932. These measurements were performed by using a Bunsen burner. Due to the divergent flow field additional transport on the balance of mass, energy and species is imposed with this method leading to limitations in accuracy. In 1993 de Goey [4] introduced a method based on Heat Flux measurement at a Flat Flame burner. The laminar burning velocities at methane to oxygen ratios varying between 1.11 and 1.47 are known to be in the range of 10-50 cm/s [2]. Due to this, it is possible to apply a Heat Flux Burner [4, 5] to accurately determine the laminar burning velocity.

At the Engler-Bunte-Institute Division of Combustion Technology (EBI-VBT) a flat flame burner system was designed according to the Heat Flux Method [5]. Some modifications have been applied to the burner head considering the proposals made by Bosschaart [6] to reduce the influence of the burner head on measured laminar burning velocities. The Heat Flux burner was validated with methane-air mixtures at different equivalent ratios (0.77 – 1.43).

Experimental setup

The current Heat Flux burner setup allows determining laminar burning velocities up to 50 cm/s of various gaseous fuels and oxidizers. It is also possible to vary the pre-heating temperature from 263 to 453 K. The new burner head consists of two parts which are hard bolted together. A burner plate and the supporting structure, representing the first part, are made of brass. The second part is a heating jacked made of stainless steel.

This setup is used to determine the adiabatic laminar burning velocities of methane and pure oxygen mixtures at different preheating temperatures and fuel to oxidizer ratios.

Conclusions

Measured laminar burning velocities in the considered range are lower than the published data by Jahn [3]. The influence of pre-heating temperature was analysed and interpreted using the power law correlation $S_L = S_{L0} (T/T_0)^{\alpha}$ from literature, e.g. [7, 8].

During experiments a heavy sooting diffusion flame was observed downstream of the premixed flame. Further investigations on the influence of the diffusion flame will be conducted in the future.

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