A comparative study of laminar burning velocities of methane, methanol and ethanol using the Heat Flux method

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Introduction

The laminar burning velocity is a fundamental property of a reactive fuel-oxidizer mixture, depending on a mixture composition, ambient pressure and initial temperature. Reliable experimental data on laminar burning velocities are essential for validation of chemical reaction mechanisms. These data are also often needed in designing of different industrial and domestic burners. There are several experimental methods to measure laminar burning velocity: the Bunsen flame method, the spherically expanding flame method, the stagnation flame method and the flat flame burner method, including the Heat Flux method. A detailed overview of different methods can be found in [1] and [2].

In this study the Heat Flux method has been applied to measure laminar burning velocities of methane, methanol and ethanol mixtures with air at atmospheric pressure. In order to improve the measurements, check their reproducibility and determine possible systematic uncertainties, several sets of experiments have been carried out. The measurements have been performed by four different laboratories from Eindhoven University of Technology (TUE), Lund University (LU), OWI Oel-Waerme Institut GmbH (OWI) and TU Bergakademie Freiberg (TUBaF).

Experimental results

To evaluate the performance of the Heat Flux method, several sets of experiments have been carried out and their results have been compared. Three different fuels have been investigated at atmospheric conditions – one gaseous fuel (methane) and two liquid fuels (ethanol and methanol). The initial temperature was equal to 298 K for methane, 318 K for ethanol and 298 and 318 K for methanol.

As an example, the results for methane are presented:

I. Methane (CH_4)/air mixtures

In Figure 1 the laminar burning velocities of methane/air mixtures for equivalence ratios from 0.7 to 1.3 at 298 K and 1 atm are presented. Among equivalence ratios used the maximum mean burning velocity (38.1 ± 0.7 cm/s) was measured at an equivalence ratio of 1.1. The figure shows that the experimental results of OWI and TUBaF are very close to each other and only small deviations can be detected. At equivalence ratios of 0.7 and

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0.8 the results of all labs agree quite well with each other. At equivalence ratios of 0.9 and 1.0 the results of TUE and LU are higher by about 0.8 to 1 cm/s compared to other results.

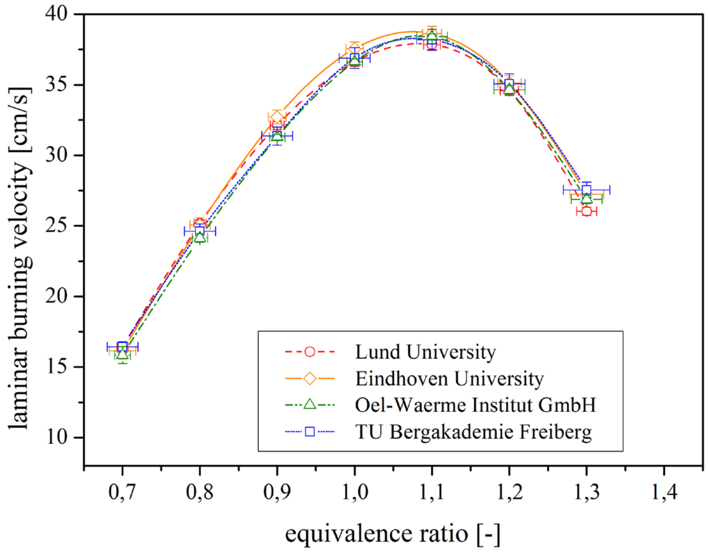

Figure 1 – *Laminar burning velocity of methane/air flames at 298 K.*

Table 2 – *Average differences between the results of different labs for methane/air mixtures at 298 K.*

	Average difference [cm/s]		
	TUBaF	OWI	TUE
LU	0.2	0.1	0.5
TUBaF	-	0.3	0.3
OWI	-	-	0.6

Conclusion

In this study the heat flux method has been used to measure the laminar burning velocities of three different fuels (using up to four different test rigs at four different labs). It has been confirmed that this method can produce reliable and comparable data on laminar burning velocities. The measured trends are found to be consistent for all measurements. Moreover, in more than 70% of the cases the difference between two single points measured by different labs did not exceed 1 cm/s. It should be noted, however, that there are still some unknown phenomena, which resulted in differences between the measured laminar burning velocities. Therefore, as a further step, a detailed validation of the individual test rigs (together with a harmonised uncertainty evaluation) will follow.

References

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