LAMINAR BURNING VELOCITIES OF ETHANOL-WATER MIXTURES

R. Haas-Wittmüß*, R. van Duren, R.T.E. Hermanns

OWI Oel-Waerme-Institut GmbH, Affiliated Institute of RWTH Aachen

Abstract

The increasing use of biofuels as a replacement for fossil fuels requires gaining insight in fundamental combustion properties especially as a function of ageing processes. Ethanol is broadly produced from biomass and has a well-established infrastructure as a surrogate for gasoline fuels. Globally, Ethanol is blended into gasoline fuels in increasing amounts to lower the carbon footprint of transportation fuels. One of the ageing indicators of ethanol is the water content. Ethanol exhibits a hygroscopic behaviour, meaning while storing ethanol in contact with humid air result in rising water content of the fuel by time. Wrong storage of the fuel can therefore result in undesired high water contents.

As one key property, the adiabatic laminar burning velocity is being investigated for ethanol with different water contents. The Heat Flux method [e.g. 1-4] is used to measure the adiabatic laminar burning velocity. As fuel, pure ethanol (99 %) is mixed with different amounts of deionized water to create mixtures of 10, 20, and 30 volumetric percent (vol.-%) water content. The results of the experiments are herein compared to pure ethanol. Numerical simulation with an ethanol mechanisms, namely San Diego [5] and Leplat et al. [6] are used to estimate the influence on the adiabatic laminar burning velocity by the increased water content.

The work will show results from a variation of the fuel-air-ratio in the range of $\varphi = 0.7 - 1.4$ at an unburnt mixture temperature of $T_u = 318$ K and atmospheric pressure. The applied setup with a heated porous media evaporator show its limitation with water contents above 20 vol.-%, since the evaporation of the ethanol blend with 30 vol.-% water exhibits instabilities. The stabilized flame showed corresponding instable behaviour. The results with water contents of 10 and 20 vol.-% show a good correlation with the predicted numerical results. Preliminary results are shown in Figure 1, comparing pure ethanol to results of the San Diego mechanism (lines), as well as initial values for ethanol-water mixtures.

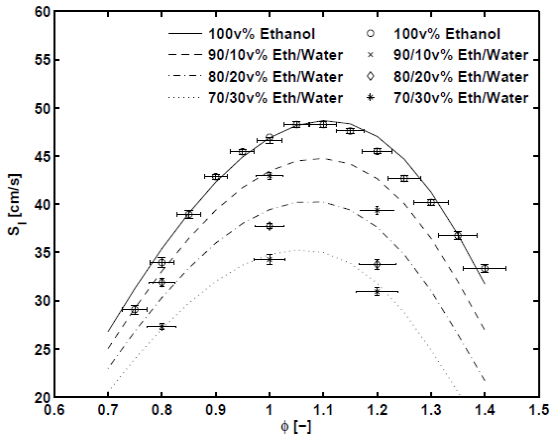

Figure 1: Laminar burning velocity as function of the equivalence ratio of ethanol-air at T=318 K and 1 atm. Lines: San Diego mechanism, Markers: Experiments

References

[1] Bosschaart, K.J., L.P.H. de Goey. Combustion and Flame, 132, 1–2, 2003, 170–180.

[2] Vancoillie, J., M. Christensen, E. J. K. Nilsson, S. Verhelst, and A. A. Konnov. Energy Fuels, 26, 3, 2012, 1557–1564.

[3] J. van Lipzig, E. Nilsson, L. de Goey, A. Konnov, Fuel, 90, 2011, 2273-2781

[4] A. Konnov, R. Meuwissen, L. de Goey, Proc. Combust. Inst. 33, 2011, 1011-1019

[5] UCSD Mechanism, "Chemical-Kinetic Mechanisms for Combustion Applications", Mechanical and Aerospace Engineering (Combustion Research), University of California at San Diego (available at: http://combustion.ucsd.edu).

[6] N. Leplat, P. Dagaut, C. Togbe, J. Vandooren, Combustion and Flame, 158, 2011, 705-725

* Corresponding author
Email address: r.haas-wittmuess@owi-aachen.de