

A novel data consistency analysis for experimental laminar burning velocities of $\text{NH}_3\text{-H}_2$ mixtures for kinetic model validations

Xinlu Han^{1*}, Kaidi Wan^{2,3}, Tibor Nagy⁴

*lead presenter: hanxinlu@upc.edu.cn

1 College of New Energy, China University of Petroleum (East China), Qingdao 266580, PR China

2 Aircraft and Propulsion Laboratory, Ningbo Institute of Technology, Beihang University, Ningbo 315800, PR China

3 National Laboratory for Computational Fluid Dynamics, School of Aeronautic Science and Engineering, Beihang University, Beijing 100191, PR China

4 Institute of Materials and Environmental Chemistry, HUN-REN Research Centre for Natural Sciences, Budapest, Hungary

Ammonia (NH_3) is a promising carbon-free fuel, where the H_2 enrichment strategy often adopted to enhance the combustion. One of the fundamental combustion properties, the laminar burning velocity (S_L), has been extensively investigated in the literature. Many measurements providing laminar burning velocity data are available, but exhibited significant data scatter, i.e., inconsistency much beyond the reported uncertainties among different experimental results under the same conditions. The present study focuses on the data consistency of NH_3+H_2 laminar burning velocities. To complement the existing literature datasets for consistency analysis, experiments were performed using the heat flux method at 298 K and 1 atm, and at various equivalence ratios, oxygen ratios, and H_2 blending ratios (x_{H_2}). Based on simulations of five widely-used kinetic models from Han, Stagni, Konnov, Shrestha, and KAUST, linear relationship was found between $\ln S_L$ and x_{H_2} across a broad range of conditions, with sensitivity analysis highlighting the underlying physio-chemical reason. Based on this linear relationship, a new data consistency criterion was proposed. Through the new and the previously existing criteria, 12 consistent experimental datasets were identified from the 20 available datasets of $\text{NH}_3+\text{H}_2+\text{N}_2+\text{O}_2$ laminar burning velocities (already excluding those without stretch or heat loss corrections). The present consistency analysis noticeably reduced the data scatter ranges, e.g., for 60% NH_3 +40% H_2 +air laminar burning velocities at 298 K and 1 atm, it was reduced from 9 cm/s to 3 cm/s, the latter being comparable to the reported experimental uncertainties. In addition to the found consistent data sets, which were suggested for future model validation and optimization studies, the present methodology using all available data consistency criteria has potential to help other fuel systems to filter out less reliable data sets, effectively overcoming the data scatter from different measurements.

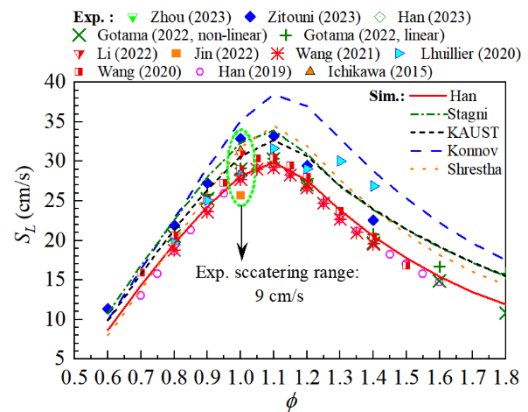


Fig.1. Laminar burning velocities of 60% NH_3 + 40% H_2 + air flames at 298 K and 1 atm

Acknowledgments: This work was supported by the National Natural Science Foundation of China (52206189, 52076008), and the Hungarian National Research, Development and Innovation Office (FK1334332, K147024).