Experimental error assessment of laminar flame speed measurements for optimization of chemical reaction models with PrIMe

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The past decades have seen a renewed importance in uncertainty quantification and error assessment [1-8]. The expanding growth of the amount of experimental data used in combustion studies needs advanced technologies for collecting and evaluating these data. PrIMe [9] has received much attention over the last decades as one of the most promising cybersystems offering kinetic database platforms, calculation and data analysis tools. In the database platform, namely Warehouse, data is stored in form of Extensible Markup Language (XML) files. These data can be used for data analysis tools implemented in PrIMe, such as Bound-to-Bound Data Collaboration (B2BDC) [10-15]. B2BDC is a computational framework developed for a treatment of collective information content (combined numerical and experimental data) collected from multiple sources and stored in the Warehouse in XML format. This approach allows the users to investigate the studied data consistency, identify the sources of inconsistency, evaluate (and re-evaluate) data uncertainty and optimize models under development.

This paper focuses on error assessment of experimental techniques for laminar flame speed measurements. Most common flame speed measuring techniques, Heat Flux Method, Bunsen Flame Method, method of spherically symmetric flame (Spherical Flame Method) and Countercurrent (Counterflow) Method, have been analyzed and their possible sources of experimental data errors have been investigated in order to optimize the digitization of the experimental data in the future. The respective principles and the structure have been described.

For each of the methods presented here possible sources of data errors have been identified. These errors have been classified as intrinsic errors and parameter-dependent errors. It was found that the described experiments share some sources of error, e.g. specific burner / nozzle / chamber characteristics, air composition, temperature variation, calibration / measuring devices, pressure, stoichiometry, fuel specific properties and extrapolation method, etc.

Furthermore, individual error sources have been identified, e.g. such as the cooling / heating system of the HFM, CoFlow or pilot flame using the Bunsen flame and countercurrent method, product residues in the combustion chamber, ignition delay and measuring radius in the case of the spherically symmetric flame method and the nozzle spacing ratio of the counterflow method.

The results of the data error analysis including the error parameters have been systematically summarized. Furthermore, based on the conducted analysis, the XML code has been supplemented with the error parameters for XML files optimization and the data transmission. With this process, a machine-readable file has been created, which can be stored in the database and contains the sources of error. This file can now easily be linked to software for calculating the errors and allowing the automated calculation of the error without the constant intervention of humans. Afterwards, the software captures the fields and sums up the found errors depending on the given and stored criteria.

This study is the first step towards enhancing our understanding of error assessment of laminar flame speed measuring techniques. We hope that our research provides a powerful methodology for the improvement of experimental data digitization, so that the modeling of the

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chemical reaction mechanisms within B2BDC provides accurate predictions of the fuel behavior based on laminar flame velocities.

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