

Experimental data of the TU Delft partially premixed swirl stabilized CH₄/H₂ burner

Description:	This is the data set of the TU Delft partially premixed swirl stabilized burner developed within the APPU project. The dataset contains both non-reacting and reacting flow fields obtained by PIV, emission data and OH-PLIF data (qualitative).
Facility	TU Delft Sustainable Aircraft Laboratory, swirl stabilized APPU combustor
Contributors	Sarah Link, Francesca de Domenico, Arvind Gangoli Rao, Georg Eitelberg
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Date measurements:	March 2023 , July 2024 and January 2025

Relevant Publications

- S.Link et. al. Experimental analysis of dual-fuel (CH₄/H₂) capability in a partially-premixed swirl stabilized combustor, IJHE, doi: [10.1016/j.ijhydene.2024.12.286](https://doi.org/10.1016/j.ijhydene.2024.12.286).
- S.Link et al. Experimental and numerical investigation of mixing in a partially premixed CH₄/H₂ combustor, IJHE, [10.1016/j.ijhydene.2025.05.070](https://doi.org/10.1016/j.ijhydene.2025.05.070)”
- S.Link: Flame stability and Emissions in methane-hydrogen combustion - Designing for fuel flexibility. Dissertation TU Delft 2025

1. Test Configuration

The Experiments were performed in the Sustainable Aircraft Laboratory at TU Delft. Figure 1 (left) shows a photo of the swirl stabilized set-up installed in the TUD lab. The right side shows a schematic of the swirl stabilized burner. A detailed view of the injector is shown as well as the locations of the measurement techniques which are relevant for this data set. The exact dimensions can be found in the publication “S.Link et. al. Experimental analysis of dual-fuel (CH₄/H₂) capability in a partially-premixed swirl stabilized combustor, IJHE, doi: [10.1016/j.ijhydene.2024.12.286](https://doi.org/10.1016/j.ijhydene.2024.12.286).

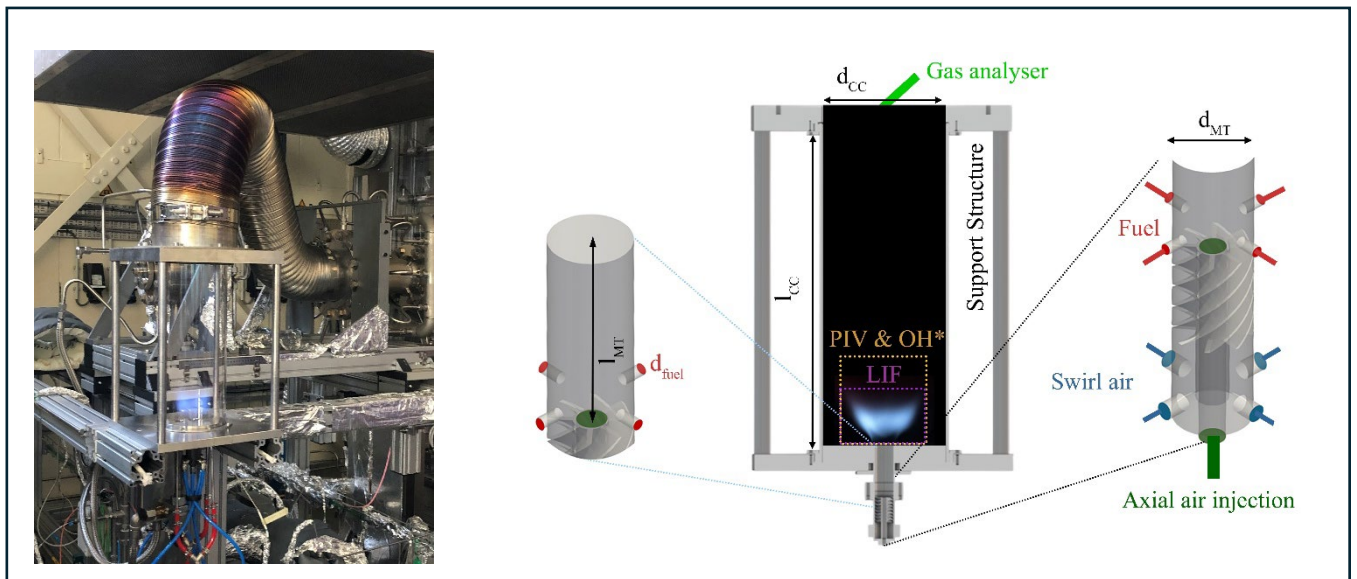


Figure 1: Swirl stabilized set-up installed in the TUD lab and schematic of the set-up

2. Non-reacting flow fields

Non-reacting flow fields were obtained by PIV, by seeding the airstream with DEHS droplets. The CH₄/H₂ fuel was substituted with He/air mixtures at the design point of 12kW. The exact procedure for this can be found in the publication “S.Link et al.

Experimental and numerical investigation of mixing in a partially premixed CH₄/H₂ combustor, IJHE, [10.1016/j.ijhydene.2025.05.070](https://doi.org/10.1016/j.ijhydene.2025.05.070)”. Average flow fields are present for the mixing tube and for the combustion chamber. The naming convention for these measurements are the following

- H₂ = hydrogen content in mole fraction in the reacting case
- AAI = level of AAI, given as percentage of the total air flow rate

- J = momentum flux ratio between fuel and air. Changing J is achieved by changing the fuel inlet diameter. Given in low, mid or high, the exact values for the diameters and J can be found in [10.1016/j.ijhydene.2025.05.070](https://doi.org/10.1016/j.ijhydene.2025.05.070)

The data is provided in .dat format. The files were generated with the software davis 10, by calculating the velocity fields with a multipass cross-correlation approach with decreasing window size (128x128 to 16x16 pixels for the combustion chamber and 64 x 64 to 12 x 12 pixels for the mixing tube, both with 75% overlap).

In addition to the average flow fields, the results of the Spectral Proper Orthogonal Decomposition (SPOD) are provided. The open-source software SPOD is used (found under https://github.com/SpectralPOD/spod_matlab). The code was run with the following parameters: frequency 1kHz, block length 512, 50% overlap, which results in a final frequency resolution of 4 Hz.

In the folder spatial modes, the x-component and y-component of the SPOD mode is provided in .dat format. The first column in the file corresponds to the x-values, the second y-values, third x-component of velocity and forth column the y-component of velocity. The last column can be disregarded. The size of all the flow fields in the non-reacting case is **512x512**, so the columns in the .dat files have to be converted into matrices first.

The folder temporal modes contains the temporal modes (of the corresponding spatial mode) which are used to calculate the frequency spectrum. They are given in .csv format. The first column indicates the time step (frequency 1000Hz) and the second the coefficient value, which has to be used to determine the frequency spectrum.

3. Reacting flow fields

The reacting flow fields were obtained by PIV by seeding the air stream with TiO₂ particles. The naming convention for the data is the following

- Sw = Geometric swirl, either 0.7 or 1.1
- P = Thermal power
- H₂ = Hydrogen content in mole fraction
- AAI = level of AAI, given as percentage of the total air flow

A more detailed description of the methodology (swirler design, design operating conditions) can be found in S.Link [10.1016/j.ijhydene.2024.12.286](https://doi.org/10.1016/j.ijhydene.2024.12.286)

The data is provided in .dat format. The files were generated with the software davis 10, by calculating the velocity fields with a multipass cross-correlation approach with

decreasing window size (96x96 to 32x32 pixels with 50% overlap). The files with names **Av** contain the average flow field, while the files with name **Stdv** contain the average standard deviation. The files can be opened with a txt reader.

The first column in the file corresponds to the x-values, the second y-values, third x-component of velocity and forth column the y-component of velocity. The last column can be disregarded. The size of all the flow fields in the reacting case is **114x101**, so the columns in the .dat files have to be converted into matrices first.

4. OH-PLIF

OH PLIF data is qualitatively provided for the design point of 12kW at the baseline conditions. The same name convention of 3. reacting flow fields applies here. Similarly, the same geometry is used. Operating conditions and geometry are described in [10.1016/j.ijhydene.2024.12.286](https://doi.org/10.1016/j.ijhydene.2024.12.286). The data was generated with the Davis 10 Software, by exciting the OH radical with a wavelength of 293.636 nm.

The data is provided in .dat format where the first column is the x-coordinate, the second the y-coordinate and third the OH PLIF intensity. The other columns can be disregarded. The size of the matrix is 1214x1024.

5. Emission data

Emission data (NO and CO₂) where measured with an ABB gas analyzer in the outlet plane of the combustion chamber, for P = 12 kW (Subfolder baseline). Emissions where checked for steady state and averaged over at least 20 seconds. The remaining emissions (NO₂, CO, CH₄) are not shown as their values were negligible. The data is provided for different powers P and different hydrogen contents (for the definition of P see [10.1016/j.ijhydene.2024.12.286](https://doi.org/10.1016/j.ijhydene.2024.12.286)).

The name convention is as follows:

- Sw = geometric swirl number, 0.7 or 1.1
- AAI = level of AAI given in percentage of the total air flow
- XH₂ = hydrogen content in mole fraction

Each .txt file contains the average values and standard deviations for different levels of P and different hydrogen contents XH₂.

In addition to the baseline case, NO values are shown for two momentum flux ratios J (Sub folder effect of J). The emissions (average and standard deviation) are shown for a fuel inlet diameter 3.5mm (J_{low}) and 2 mm (J_{high}). For more detailed information on the measurements refer to the Dissertation of TU Delft: Sarah Link: Flame stability and emissions of methane-hydrogen flames - Designing for flexibility (TU Delft, 2025).