TCS5: Guidelines for the TU Delft target flame (H_{II})

Researchers working on modeling of turbulent spray combustion are invited to perform simulations of the Delft Spray-in-Hot-Coflow (DSHC) ethanol flame H_{II} and to submit their results for presentation at the TCS5 workshop. This note describes the experiment and the database and provides guidelines for contributors.

1. Description of the target flame

Experimental setup

The Delft Spray in Hot Coflow (DSHC) database contains results of an experimental investigation of spray flames generated using a laboratory-scale burner. The main publications on these experiments are the journal publications [1,2] and the PhD thesis by Hugo Rodrigues [3].

The flow configuration used consists of a spray jet injected into a coaxial upward flow of either air or combustion products from a secondary burner operating in lean conditions. The latter case resembles an environment with temperature and oxygen concentration typical for combustion in highly diluted air diluted (flameless combustion or MILD combustion). By using a secondary burner the properties of the fluid entrained in the near burner zone of the primary burner are controlled independently of the progress of combustion in the spray flame or the flue gas composition downstream of the flame. By varying the product stream from the secondary burner it is possible to systematically study a range of different conditions in the spray flame. The spray is created using a commercial pressure-swirl atomizer. Ethanol and acetone were used as fuel because of their well-known physical properties and the availability of detailed and reduced chemical mechanisms for the combustion process.

The database contains cases with differences in fuel (ethanol or acetone), in type of coflow (air or lean combustion products), in fuel injection pressure and in coflow properties (variation in temperature and oxygen concentration). These cases are briefly described in Appendix 1.
The selected target flame for TCS5, named H_{II}, is an ethanol flame in a coflow with mean oxygen concentration 9.2% O_2 by volume.

Characteristic parameters for the target flame are given in the Table 1.

		H_{II}
Fuel		Ethanol
Fuel mass flow rate	kg/h	1.46
Fuel injection pressure	bar	11.5
Fuel temperature	K	301
Coflow mean velocity	m/s	2.243
Coflow mean temperature	K	1200
Coflow mean oxygen volume fraction	%	9.2

Measurement techniques

High-speed visualizations of liquid breakup were performed to provide insight on the atomization mechanisms. Complementary laser based diagnostic techniques, PDA and CARS were employed to characterize the properties of gas and liquid phase in the spray region. PDA provided simultaneous measurements of droplet velocity and size statistics and CARS the gas-phase temperature statistics. The velocity and temperature statistics of the coflow were measured using respectively LDA and CARS. The composition of the coflow was measured using a flue gas analyzer. The coflow measurements together with the measurements in the spray region as close as possible to the atomizer (8 mm from nozzle exit), provide a dataset of inflow boundary conditions useful for numerical simulations.

Guidelines

Persons interested in doing numerical studies of the target case should send e-mail to D. Roekaerts (d.j.e.m.roekaerts@tudelft.nl). They will receive the experimental database and further information on known previous numerical studies, on topics of special interest and on guidelines for format of submitted results.

Acknowledgement

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References

1. Hugo Correia Rodrigues, Mark J. Tummers, Eric H. van Veen, Dirk J.E.M. Roekaerts, Spray flame structure in conventional and hot-diluted combustion regime, Combustion and Flame, 2014
http://dx.doi.org/10.1016/j.combustflame.2014.07.033

2. H. Correia Rodrigues, M.J. Tummers, E.H. van Veen, D.J.E.M. Roekaerts, Effects of coflow temperature and composition on ethanol spray flames in hot-diluted coflow, Int. J. Heat Fluid Flow, 2014, http://dx.doi.org/10.1016/j.ijheatfluidflow.2014.10.006

3. Hugo Rodrigues, Spray combustion in moderate and intense low-oxygen conditions. An experimental study, PhD Thesis, Delft University of Technology, 2015 (becoming available on http://repository.tudelft.nl soon)

Appendix 1: Overview of cases in the DSHC database

Ref. [1] presents a comparative study of ethanol reacting sprays in air and in hot-diluted coflow. The label given to these two cases respectively is A_{II} and H_{II}. The characteristic parameters of the cases are listed in Table 1 of Ref. [1] (identical to Table 3.1 of Ref. [3]). A summary of the measurement locations for LDA, CARS, flue gas analyser and PDA is given in Table 2 of Ref. [1] (identical to Table 3.2 of Ref. [3].)

Ref. [2] presents a comparative study of ethanol reacting sprays in different hot-diluted coflow conditions. The label given to the studied cases are H_I, H_{Iaux} ,H_{II}, H_{IIaux} and H_{III}, with H_{II} a case already studied in Ref. [1].

The three cases H_I,H_{II}, and H_{III} have different composition and temperature of the coflow and also different mass flow rate of the spray. The auxiliary cases H_{Iaux} and H_{IIaux} were added to study the role of injection pressure (i.e. mass flow rate of the spray). The characteristic parameters of all cases are listed in Table 1 of Ref. [2] (identical to Table 4.1 of Ref. [3]). A summary of the measurement locations for LDA, CARS, flue gas analyser and PDA is given in Table 2 of Ref. [2] (identical to Table 4.2 of Ref. [3].)

Ref. [3] contains the results of Refs. [1] and [2] and in addition reports on a comparison of ethanol and acetone sprays in an identical hot-diluted coflow. The ethanol case is the case H_{III}, already studied in Ref. [2]. The case with acetone as fuel uses a coflow condition identical to that of H_{III} and is labeled AcH_{III}.