Engler-Bunte-Institute
Combustion Technology
Engler-Bunte-Ring 7
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Bachelor's or Master's Thesis

Stability analysis of laminar iron dust flames

Motivation

Iron particles can be used in a closed cycle as a carbon-free chemical energy carrier for storing renewable energy. In this cycle, iron oxide particles are reduced using green hydrogen, enabling the storage of renewable energy in the form of metallic iron. Spatially and temporally decoupled, the resulting iron particles are oxidized, releasing energy. The generated heat can be utilized for industrial processes or electricity generation. To investigate fundamental phenomena during the high-temperature oxidation of micron-sized iron particles, a Bunsen-type burner was developed at the Engler-Bunte Institute that enables the stabilization of iron dust flames over a wide operating range. Outside the stable operating regime, undesirable effects such as oscillations, flashbacks, or flame blow-off may occur. Figure 1 shows representative images of an iron dust flame during blow-off, stable operation, and flashback conditions. To ensure safe and controlled operation in combustion processes, a thorough understanding of the stable operating range of the flame is essential. Flame stability strongly depends on operating conditions such as flow velocity, particle concentration, oxygen content, co-flow, and preheating temperature.

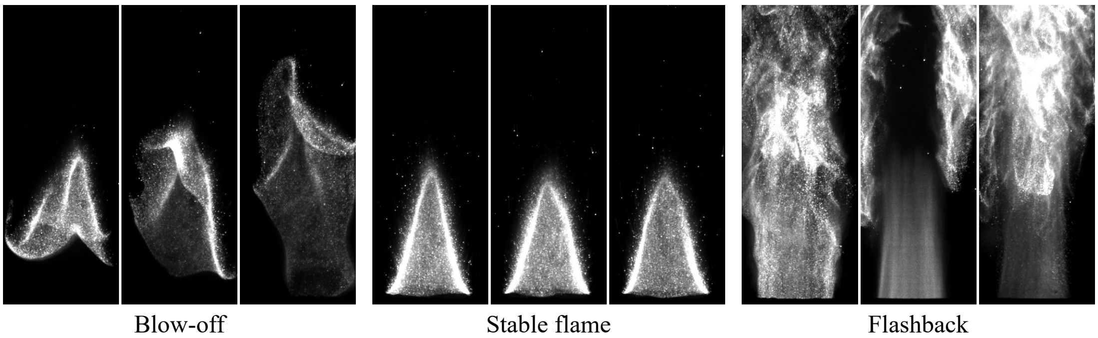

Abbildung 1: Examples of single-shot images of an iron dust flame during blow-off, stable operation, and flashback conditions (from left to right).

Project description

The objective of this work is the investigation of the stability of laminar iron dust flamesunder varying operating conditions. The stability analysis is based on particle emissions and the apparent flame structure, captured under different operating conditions using an suitable imaging techniques. To quantitatively characterize flame stability, a suitable stability parameter is identified. By implementing an automated evaluation routine, the selected parameter is quantified across the investigated experimental boundary conditions. The evaluation routine is assessed through a sensitivity analysis with regard to its accuracy and robustness. The acquired measurement data are analyzed, interpreted, and physically contextualized.

The specific focus of the work may be adapted flexibly according to individual interests, start date, and project progress.

Tasks

- Literature review on on iron dust combustion, imaging techniques, and quantitative parameters to characterize flame stability
- Time-resolved imaging of particle emissions under varying operating conditions
- Identification of a suitable stability parameter to quantitatively characterize flame stability
- Implementation of an automated evaluation routine to quantify the selected stability parameter

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- Sensitivity analysis to assess the methodology, accuracy, and robustness of the evaluation routine
- Analysis of the influence of varying operating conditions on flame stability and determination of the stable operating range of the laminar iron dust flame
- Documentation and critical assessment of the measurement methodology, measurement uncertainties, and obtained results

Background knowledge

Students of engineering or related disciplines. Prior experience with MATLAB or Python is beneficial but not required. An interest in experimental work and/or data analysis is expected.

Date, location

Starting immediately, Campus South

Contact

If you are interested, feel free to contact us:

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