Institut für Technische Verbrennung

RWTH AACHEN UNIVERSITY

Master thesis

Modeling of aluminum particle combustion

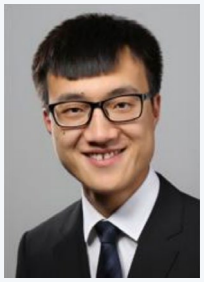
Topic is suitable for

✓ Master thesis

Field of activity

Multi-physics reacting flows

Contact Person



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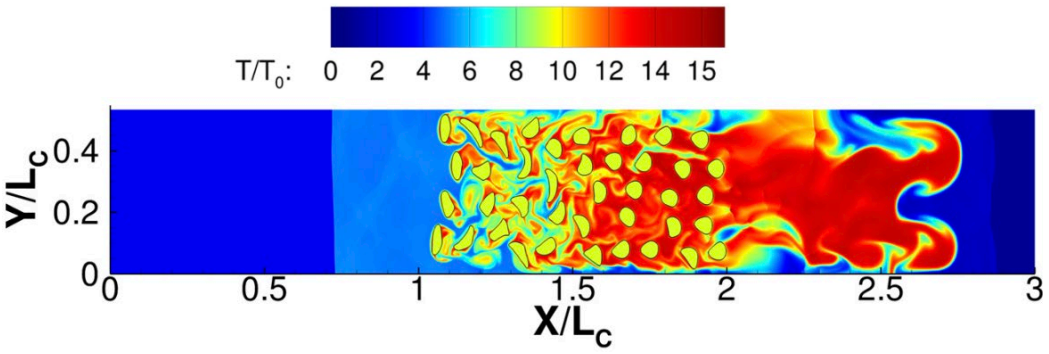
Aluminum (Al) is a promising future source of energy due to its high energy density, easy transferability, huge earth deposits, and clean combustion products. Recently, aluminum powders are found to present great potential as an alternative fuel in a low-carbon economy. In this application scenario, aluminum/air suspensions can be combusted at scales comparable to power generation, while the combustion products are mainly solid alumina without carbon dioxide. In this context, the proposed thesis focuses on fine micron-sized aluminum powders, which are proven to have fast reaction rates owing to their high specific surface area.



In the proposed thesis, numerical simulations of aluminum particle combustion will be performed using our in-house code CIAO. The Eulerian-Lagrangian method will be applied, where the aluminum particles will be numerically described by Lagrangian particles, which are transported by the flow and react with the gas mixtures. First, single-particle combustion will be simulated and validated with data available in the literature. Then multi-particle combustion simulations will be conducted. The analysis will focus on the flame speed of the particle combustion and its response to flame stretch.

This thesis will be co-supervised by Mr. Hongchao Chu and Mr. Pooria Farmand. The supervisors possess considerable proficiency in numerically investigating the gas phase and particle combustion. The numerical framework and analysis tools have been previously developed and utilized in hydrogen and coal particle combustion [1-4]. In the proposed study, the particle combustion model will be extended to consider the aluminum combustion mechanism. The study is part of a BMBF project, a collaboration between four institutes and companies in Germany and Canada, which includes numerical and experimental investigations.

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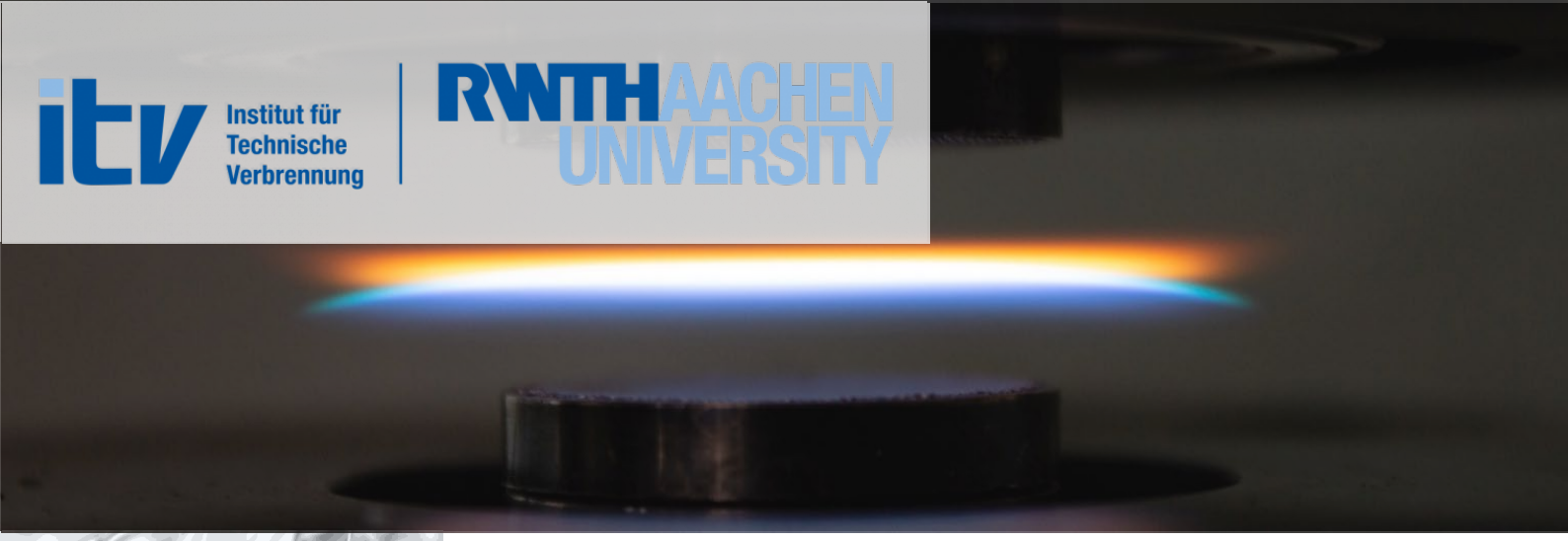

Tasks:

- Validation of the newly developed model for aluminum particle combustion
  - Visualization of the simulation results using Paraview
  - Evaluation of the variables of interest using Python or Matlab scripts
  - Validation using single particle combustion configuration

- Simulations of laminar multi-particle combustion with parameter variation
  - Equivalence ratio
  - Particle concentration
  - Flame stretch rate
  - Validation using the experimental data in the literature

- Analysis of the effects of the flame stretch using Python or Matlab scripts
  - Effects on the flame speed
  - Effects on the equivalence ratio
  - Effects on the temperature
  - Effects on the flame structure

Our Offer:

- Close supervision with integration into the research group
- A relevant, state-of-the-art research topic that can be adjusted to your interests

Requirements:

- Enthusiasm about programming and numerical modeling
- Interest in fluid dynamics and thermodynamics

References:

[1] P. Farmand et al., Combust. Flame, (2022)

[2] A. Attili, P. Farmand, et al. Flow Turbul. Combust. (2021)

[3] H. Chu et al., Proc. Combust. Inst. (2022)

[4] H. Chu et al., Combust. Flame, submitted for publication (2023)