Lehrstuhl für
Aerodynamik und
Strömungsmechanik

Term paper/master's thesis

Real-gas combustion in CH4/O2 rocket combustion chambers

theoretical/simulative

Modern rocket engines, in order to maximize the energy generated from the combustion of oxidant and oxidizer, work at extremely high operative pressures. In the middle of the combustion chambers, where temperatures reach up to 3500 K the species can still be treated according to the ideal-gas theory. On the other hand, at the wall, where temperatures are considerably lower (maximum 800 K), the species reach thermodynamic states close to their critical point, so Van der Waals forces must be considered. Therefore, when simulating such a combustion chamber, the combustion model must rely on real-gas assumptions.

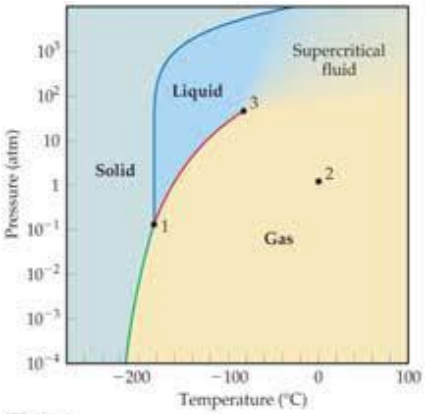

Fig. 1: Thermodynamic diagram of methane. All thermodynamic stets close enough to the critical point (3) must take into account real-gas effects.

At the Luft und Raumfahrt Lehrstuhl experiments on a film cooled methane combustion chamber have been carried out and (in the Aerodynamik und Strömungsmechanic Lehrstuhl) CFD simulations are undergoing in the attempt to match the available experimental data. The software which generates the thermodynamic tables used in the simulations is FlameMaster. FlameMaster is a C++ code developed originally at the University of Aachen which solves the flamelet equations in the mixture fraction space. The flamelet model has already been modified to account for non-adiabatic flames and for the turbulence influence. What should be done now is to improve the code to increase speed and physical accuracy and to expand it so that real-gas effects are considered.

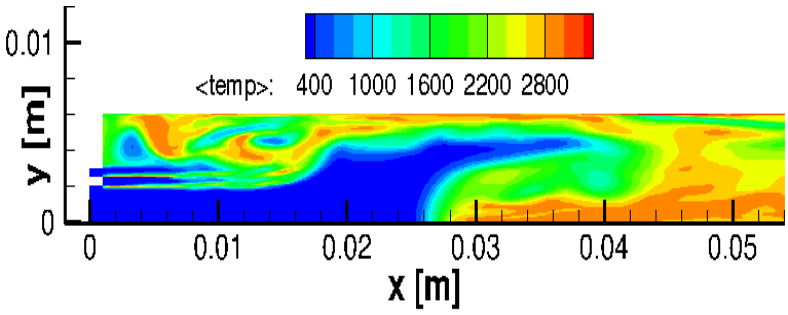

Fig. 2: R. Preliminary results on the single element combustion chamber by means of ideal-gas flemet

The work comprises the following steps:

- Familiarization with FlameMaster
- Familiarization with Matlab turbulence tool
- Efficiency study on Flamemaster
- Documentation on possible real gas flamelet implementations
- Implementation on FlameMaster of the chosen approach
- Postprocessing of the simulation results
- Comparison with experimental results from the literature

The final report should be written in English.

Start: from now on (announcement: 25.03.2019)

Requirements:

- Ability to work independently
- Basic knowledge of numerical flow simulation
- Good knowledge of thermodynamics and gasdynamics
- Moderate knowledge of C++
- Knowledge of linux advantageous

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