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MICROGRAVITY EXPERIMENTS AND NUMERICAL SIMULATIONS ON THE COMBUSTION OF SINGLE OXYGEN DROPLETS IN HYDROGEN

Abstract

In liquid rocket propulsion the LOX/LH2 system is preferably used because of its high specific impulse. Typically the fuel (LH2) enters the combustion chamber in pre-vaporized gaseous state and the oxidizer (LOX) as droplets in the liquid state. The vaporization of the LOX droplets and the mixture formation happens in the combustion chamber where these physical processes are not separated from the chemical process of combustion.

As a single droplet is the basic element of the technical spray combustion, microgravity experiments will be conducted in the Bremen Drop Tower to investigate the combustion process of a single oxygen droplet in a gaseous hydrogen environment. This under pressure conditions up to 60 bar which is in the supercritical regime regarding the fuel properties. The droplet will be ignited by a single laser spark and the combustion will be observed by shadowgraphy, Schlieren-optics, diagnostics of the chemiluminescence of the OH-radical as well as temporal and spatially resolved OH-LIF-diagnostics will be applied. Furthermore the experiments are compared to the results of numerical simulations developed in parallel. Of primary interest are the inverted character of the system with the fuel as the homogenous and the oxidizer as the dispersed phase and the transition from the initial premixed flame of a system between extremely wide flammability limits to the later diffusion flame. The main questions are: will the initial inward and outward propagating premixed flames lead to a single diffusion flame or will the combustion extinct before full oxygen vaporization and consumption? What is the thickness and standoff distance of the diffusion flame from the droplet? Will the exhaust build an ice layer on the droplets surface potentially leading to a droplets micro-explosion? Will the exhaust on the fuel rich side condensate or freeze? How do supercritical conditions affect the characteristic numbers of the aforementioned processes.

The paper describes the complex cryogenic experimental setup, the optical diagnostics, first experimental results and its comparison with results from numerical simulations.