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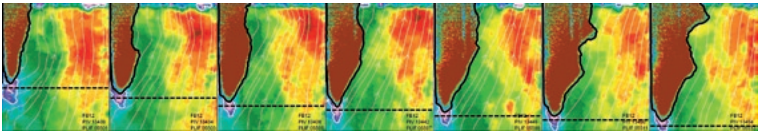
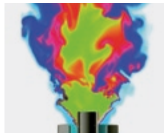
Experimental Investigation of Transient Combustion Phenomena in Turbulent Flames





Motivation

A stable combustion is essential for the operation of stationary as well as aircraft gas turbines. Nevertheless desired and undesired transient processes take place in these turbulent swirled flames. In premixed and non-premixed combustors ignition is always inevitable to start a stable reaction. The latest developments towards lean premixed combustor design reduce the pollutant emissions but also make the system prone to further transients, i.e. extinction and flashback. Especially in airborne gas turbines extinction is a major safety matter, because pressure and temperatures in high altitudes are usually very disadvantageous for reignition. Furthermore flashback can lead to the destruction of the combustion system. There the flame propagates upstream against the flow direction and typically overheats vital components. A detailed knowledge of the driving mechanisms behind these complex transient phenomena will help in the future development of lean premixed gas turbine combustors.

Method

To resolve the usually very small time scales during these processes occur, measurement systems with a very high temporal resolution are applied. All optical laser based methods are used to leave the combustion process undisturbed. Simultaneously applied planar laser induced fluorescence (PLIF) and particle image velocimetry (PIV) at several kHz repetition rate determine flame front position and velocities in two dimensions. In order to statistically investigate the turbulence-chemistry interactions during the process the spatial coordinate system is shifted from the laboratory frame onto the flame. Furthermore, a shift of time scale can be made, setting “time zero” at a significant point in the transient process, e.g. first breach of flame front during extinction. It is called “multidimensional conditioning” and defines a relative reference for comparing different realizations of the same process.

The device currently under test is a turbulent TECFLAM-burner. In this burner the fuel (methane) enters the mixing chamber through a circular pipeline and mixes there with the oxidiser (air). This methane-air-mixture flows through a variable swirl-generator and leaves the burner through the nozzle. The resulting flame is a swirled, turbulent flame which can be operated at critical conditions close to flashback and has an optical access from all sides. The spectroscopic investigations are conducted above the burner exits as well as inside the nozzle which can be exchange with a quartz glass tube to allow for transmittance of ultra violet light.