Syngas for Gas Turbine Combustion

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Research Targets for GT-Combustion

Objectives:

• Reduction of pollutants
  - NOx at increased TIT and p
  - soot particles, UHC

• Reliability of combustion processes
  - ignition, extinction, thermoacoustic

• Fuel flexibility
  - varying natural gas quality
  - alternative fuels, syngas
Real Fuel
chemical composition not defined exactly

Ignition delay

Soot

\[ \text{NO}_x \]

CO

Heat-release

Mechanism Reduction (target specific)

Validation at technical scale

Validation at laboratory scale

Model-fuels
composition exactly defined

Validation Experiments
Current Activities

**HEGSA** „High Efficient Gas Turbine with Syngas Application“  
(EC project, started 2002)

- **Goal:** Development of a gas turbine burner optimized for syngas combustion

- **DLR-Part:** Development of a reduced reaction model for syngas combustion on the basis of detailed reaction mechanisms found in literature. Validation experiments for CFD simulations at pressures of 1 and 2 bars.

- **Problem:** No validated mechanism for syngas combustion under GT conditions exists. Validation experiments have been made only up to 2 bars.
Current Activities

ENCAP - SP2 „Enhanced Capture of CO₂“
(EC project, started 2004)

- **Goal (WP 2.3):** Test and simulation of a gas turbine combustor for H₂ combustion

- **DLR-Part:** Validation experiments under GT conditions are planned with different H₂ / N₂ mixtures at the high pressure test rig at the DLR in Stuttgart.

- **Problem:** The influence of hydrocarbons on the combustion process is not considered. No detailed measurements for validation of the simulation are planned.
Objectives of VESKO

- Development and validation of a CFD model for turbulent syngas combustion under gas turbine specific conditions

- Generation of a fundamental database for syngas combustion under atmospheric conditions and elevated pressure

- Identification of the reaction mechanisms relevant for the combustion process under GT conditions (temperature ~1400 K, pressure up to 20 bars)

- Development of a detailed reaction model, reduction and validation

- Provide an interface between gasification process and gas turbine
CFD-simulation

- Adaptation and implementation of a combustion model for the use of a reduced reaction mechanism in 3D simulations

- Evaluation of the accuracy of the combustion model and the reduced reaction mechanism

- Test-related computer simulations for preparation of experiments and interpretation of the experimental data
Development and validation of a reaction mechanism

- Experimental and theoretical formulation of a complete base mechanism

- Validation through quantitative analysis of the reaction products of different syngas mixtures in single pulse shock tube experiments (GT conditions: temperature 1400 -2000K, pressure up to 20 bars)

- Reduction of the reaction model to include approx. 20 species

- Further reduction to a global mechanism with 4-6 species, usable in CFD simulations
Investigations under atmospheric conditions

- Measurement of flame structure with planar laser induced fluorescence (PLIF)

- Measurement of the flow fields and velocity fields with particle image velocimetry (PIV)

- Measurement of temperature, mixture fraction and main species concentrations with laser Raman scattering
Investigations under gas turbine specific conditions

- Measurement of flame structure and flame stabilization zones with PLIF

Technical data of the test facility:

**fuels:**
- gaseous: mixtures of CH$_4$, H$_2$, CO, propane, N$_2$
- liquid: kerosene (up to 100 bars)

**max. pressure:** 41 bars

**Air:** max. 1 kg/s (up to 800 K)

**optical access** at 4 sides
Outlook

- Extension of the reaction model for the simulation of syngas combustion with syngas from different feed materials

- Implementation of the reaction models in commercial CFD programs

- Design and optimization of gas turbine combustion chambers for real syngas with the extended CFD programs

- Assistance to the COORIVA group in the conception, design, realization and commission of an optimized IGCC power plant
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