the HEGSA project

High Efficient Gas turbine with Syngas Application

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Introduction

The HEGSA Project is a European research project, concerning the application of syngas as a fuel for gas turbine combustion. The project is carried out is close corporation with various European utilities. Research institutes, gas turbine manufacturers and gas turbine users involved.
Syngas combustion is used in so-called Integrated Gasification Combined Cycles (IGCC). IGCC is a technology that can meet the requirements on saving primary energy resources in combination with more stringent emission limitations.

Aim of the project

The aim of the project which is carried out at the University of Twente is develop a tool that will be able to improve the thermoacoustic behaviour of syngas combustors.
This will be done by:

1. build an experimental setup with an in house designed burner on which thermoacoustic measurements will de carried out for turbulent syngas diffusion flames
2. to develop a flame transfer function of this burner
3. third to develop a model to predict thermoacoustic properties of new and existing burners.

Experimental setup

The experimental setup will exist of a 100 kW swirl burner, which is able to combust syngas under pressures up to 5 bara.
In Figure 1, the burner assembly is shown in a section view. It consists of 2 coaxial ducts. The outer duct supplies the combustion air, which is swirled radially, and the syngas is supplied through the middle duct. This flow is swirled in an axial swirler. The core element is meant to improve the flow properties of the fuel swirl and can be used to ignite the mixture with a methane flame.

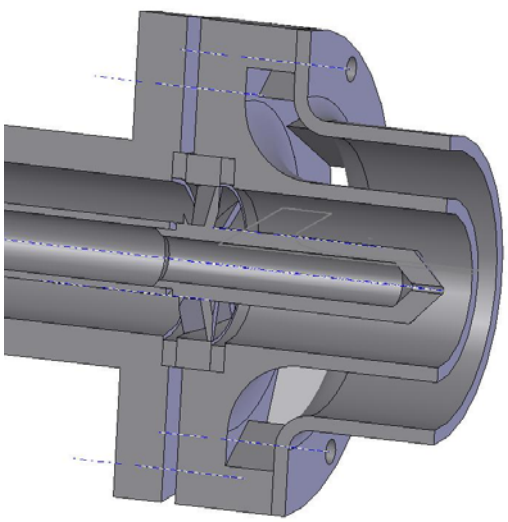

Figure 1: assembly of the experimental burner in section view

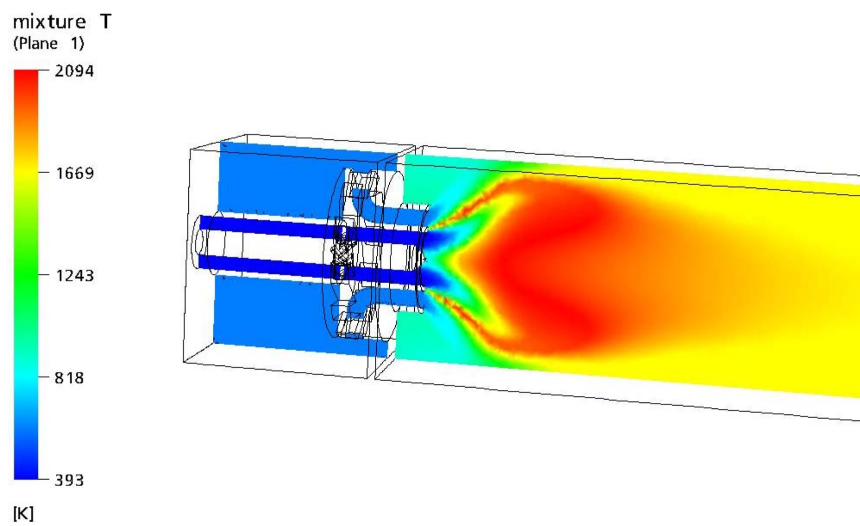

Figure 2: assembly of the experimental burner in section view

pressure [bara]	power [kW]	syngas flow [Nm^3/h]	air flow [Nm^3/h]		adiabatic flame temperature from ChemKin [K]	
			$\lambda=1$	$\lambda=2$	$\lambda=1$	$\lambda=2$
1	20	13.8	14.5	28.9	2139	1687
2	40	27.6	29.0	57.9	2139	1687
3	60	41.3	43.4	86.9	2139	1687
4	80	55.1	57.9	115.9	2139	1687
5	100	68.9	72.4	144.8	2139	1687

Table 1: mass flows in the burner of air and fuel at various mass flows

The setup will be used to do thermoacoustic measurements. These will be dynamic pressure measurements on several points in the combustor with a perturbation imposed on the fuel inlet of the burner.

Thermoacoustic instabilities in syngas flames

Thermoacoustic instabilities in syngas flames occur because of the fast combustion of this type of fuel. The coupling between perturbations of the inlet of the fuel and the heat release rate will be stronger because of the fast chemistry.

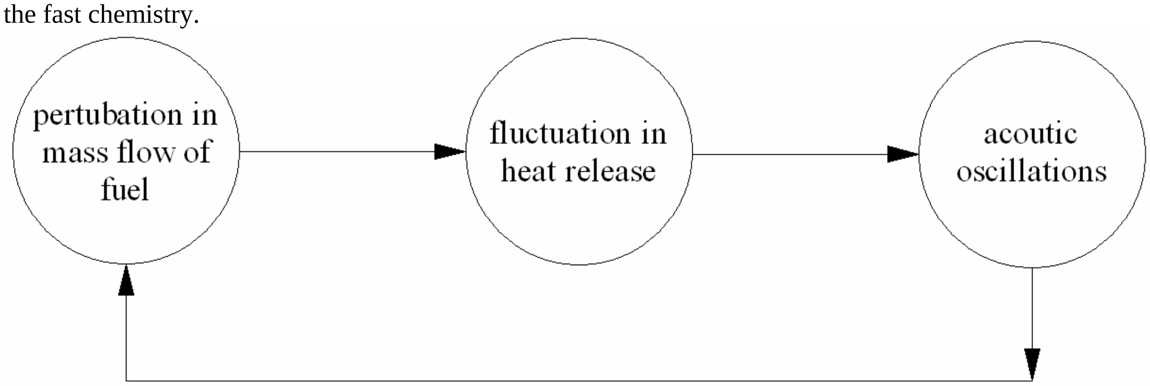

Figure 3: The relation between pertubations on the inlet of the burner with heat release rate and acoustic field

Figure 3 shows how the perturbations on the inlet and in the heat release rate are related to the acoustic oscillations. In general it starts with a perturbation in the inlet velocity of the fuel which induces a fluctuation in the heat release. This unsteady heat release excites acoustic oscillations that propagate away from the combustion region. The acoustic oscillations excite the inlet velocity of the fuel, thus closing the loop.

Flame transfer function

To be able to do predictions on the thermoacoustics of the burner, the flame transfer function is a useful tool. This function describes the transfer of the perturbations on the inlet of the burner to the heat release of the flame.

The transfer function will be derived from transient CFD calculations. When a perturbation is imposed on the inlet velocity of the fuel, the heat release will react. By integrating the total heat release rate in the combustion chamber, the flame transfer function can be determined.

It must be noted that this is something else than what was presented in Figure 3. There is a very strict separation between open and closed loops. In the prediction or measuring of the flame transfer function an open loop system is investigated. It is tested for which range of frequencies the flame gives any response. However, a perturbation which causes fluctuations in the heat release does not in any way necessitate that it be responsible for any instability.

Future work

So far, the burner is and parts of the experimental setup are designed. In the near future it will be manufactured.
The modelling of the thermoacoustics has started with the transient calculations, but has not finished yet. When the flame transfer function is derived, it will be used in a one dimensional acoustic model.