# Coupled model of gas turbine vibrations

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## Introduction

Environmental regulations require industrial gas turbines to produce less pollutants. To achieve this they are operated with an excess supply of air to combust the fuel. The downside is a less stable combustion. This leads to high acoustic pressure fluctuations, which in turn give rise to structural vibrations of the walls of the combustion chamber. This problem is studied in the EU project DESIRE (Design and Demonstration of Highly Reliable low Nox Combustion Systems for Gas Turbines).

## Objective

The objective of the project is to understand and predict the way in which structural vibrations and combustion instabilities interact in a modern high performance combustor. A combination of flame (CFD) and structure (FEM) modeling techniques is therefore needed (figure 1).

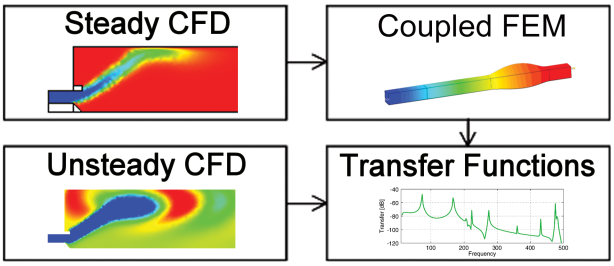


*Figure 1 : Combination of FEM and CFD techniques*

## Methods

The fundamental parts of the problem are unstable combustion, acoustics and vibration. At the core of the project are methods to couple these different subjects. The results are validated in a 500 kW experimental test-rig (figure 2).

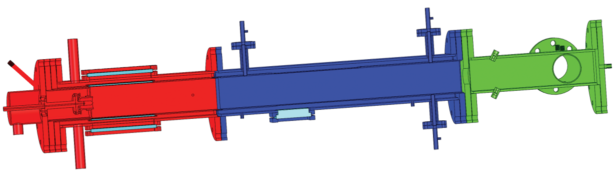

*Figure 2 : Cross-section of the test-rig*

The coupled acousto-elastic problem is studied in a coupled FEM model, using the temperature distribution from a steady CFD model of the flame (figure 1). This results in transfer functions from acoustic volume source (the flame) to structure and to the acoustic particle velocity at the burner outlet. The flame is modeled using a flame transfer function, which gives the transfer from the burner outlet to the flame as acoustic source. The transfer functions are subsequently combined in one model.

## Results

Figure 3 shows the acoustic transfer function from source to burner outlet with and without the structure.

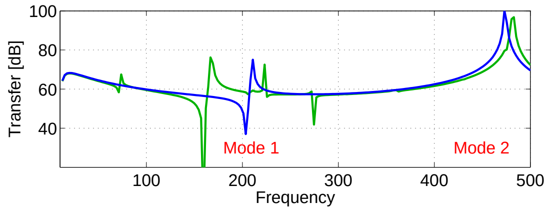


*Figure 3 : Transfer from volume source to burner outlet plane with (green) and without modeled structure (blue)*

The first peak with high gain is substantially different. The acoustic response for these peaks is depicted in figure 4.

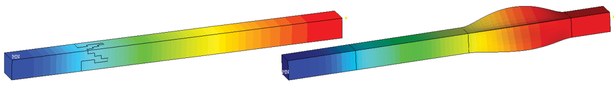

*Figure 4 : Acoustic mode shapes at the first resonance without (left) and with structure (right), quarter model*

It can be seen that the acoustic mode shape is similar, but arises at a lower frequency when the structure is present. Finally, the transfer from acoustic source to structure is depicted in figure 5.

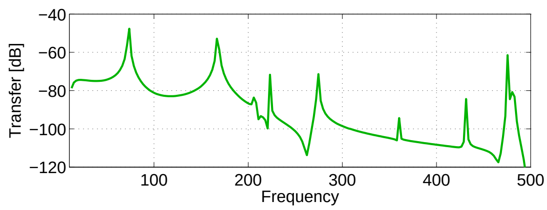


*Figure 5 : Transfer from source to structural vibration*

## Further research

- Validation using measurements
- Improve model fidelity