Vibrations in industrial gas turbines

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Introduction

More strict regulations require industrial gas turbines (figure 1) to produce less emissions. To achieve this they are operated with more air to combust the fuel. The downside of this is an increased risk of combustion instabilities. These instabilities lead to high acoustic pressure fluctuations, which in turn give rise to structural vibrations of the walls of the combustion chamber.

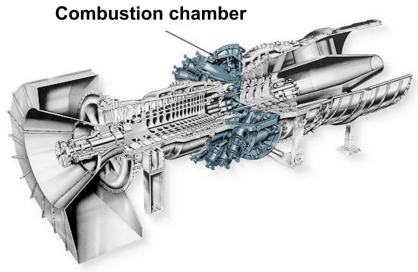

Figure 1 : Siemens V94.3a gas turbine

Objective

The objective of project DESIRE is to gain insight in the interaction between the acoustic pressure field in the combustion chamber and the vibrations of the liner wall surrounding it.

Methods

The problem will be studied using experiments and models.

Experiments A test-rig with a thermal power of 500 kW is used for the experiments (figure 2). The acoustic pressures are determined using a two-microphone technique and the structural vibrations using a laser vibrometer. Heat release in the flame is visualized using Planer Laser Induced Fluorescence (PLIF).

Models The basis for the models is a 1D acoustic model. The flame as a source of sound is modelled using the CFD code CFX5. Structural vibrations and interaction with the acoustic field are modelled using the finite element code ANSYS.

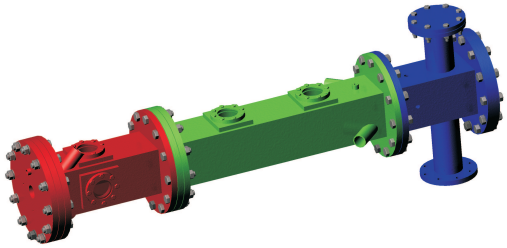

Figure 2 : Concept for test rig, red = PLIF measurements, green = structural measurements, blue = water-cooler

Results

Figure 3 shows the transfer from a point volume source to the displacement of a point on the surface. The analytical model has a 1D pressure field which excites a simply supported plate. Because this vibration in turn causes a pressure field, the FEM model has full coupling.

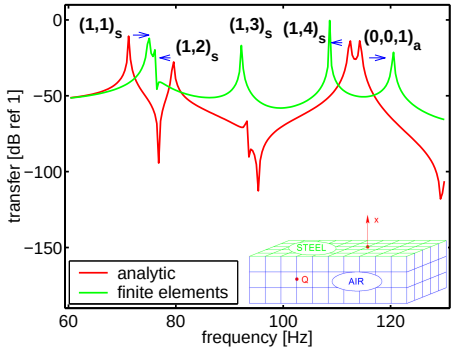

Figure 3 : Transfer volume source to displacement

It can be seen that with full coupling not only the structure is excited, but the structural and acoustical eigenfrequencies also change and become coupled. The fully coupled system will therefore have to be evaluated.

Further research

- Measurements on the test rig
- Adapt models to test rig
- Include thermal effects and other phenomena