Prediction of Thermoacoustic Instabilities in Combustion Systems - Application to a Simplified Model of a Domestic Boiler

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Abstract

The reduction of NOx emissions in combustion systems like domestic boilers, gas turbine combustors, industrial burners, etc., can be achieved by using lean premixed combustion technologies. One of the major concerns in the operability of such systems is their susceptibility to thermoacoustic instabilities. These instabilities can cause structural vibrations, increased structural wear, low-cycle fatigue, high-cycle fatigue, increased noise emissions, unsteady and inhomogeneous heat fluxes, increased heat loads. If left unattended, such phenomena can lead to damages or failures of the systems.
The design and development of new combustion systems, implementing the state-of-the-art technology for lean premixed combustion, shall take into account thermoacoustic considerations since the first conceptual design of the system.
Prediction of the thermoacoustic performances of combustion systems is fundamental in assisting the development of such system. Besides the accuracy of the prediction tools adopted, an important element is the flexibility of the tools to take into account design variations in a timely and efficient manner.
The present work describes a methodology for the prediction of thermoacoustic instabilities in combustion systems based on an acoustic network model combined with analytical formulations and numerical simulations. Acoustic FEM simulations will be used for the characterization of wave propagation paths. Analytical formulations will be used for the characterization of acoustically active elements (i.e. sources and sinks of acoustic waves). The acoustic FEM simulations consist of simulations in COMSOL Multiphysics® with "Pressure Acoustics, Frequency Domain" physics and "Eigenfrquency" study. The methodology used for the prediction of thermoacoustic instabilities is validated with test cases and applied to a simplified model of a domestic boiler.

Figures used in the abstract

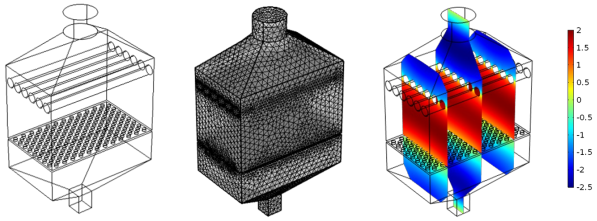

Figure 1: Domestic boiler.