LARGE EDDY SIMULATION OF COMBUSTION INSTABILITY IN GAS TURBINE ENGINES

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Abstract:
Gas turbines have become perhaps the most common methods for both energy generation and propulsion, with lean premixed combustors becoming dominant for low emissions. However, combustion instabilities, noise characteristics and pollution emissions remain a central problem. This has been exacerbated in recent years by an increasing desire to use both alternative and renewable, low calorific fuels.

Lean premixed combustion in combustors is very susceptible to large amplitude instability which can result in vibration, increase wall heat transfer, worsen engine performance and shorten life span of the system. Such problems often limit their application for low calorific fuels.

This paper presents an application of Large Eddy Simulation (LES) for gas turbine combustion instability, using published data from the European PRECCINSTA project for validation. Initially a RANS (Reynolds Averaged Navier-Stokes Method) simulation methodology was employed. This was shown to give good results for stable or time-averaged flow fields, though unsteady RANS simulations largely failed to represent the unstable flow field which is also very important.

The results demonstrated that the LES method was able to provide promising results not only for steady state time-averaged data, but also for strongly unstable flow features such as the fluctuation amplitude of the pressure or velocities. Additionally, LES was used to predict the combustor instability modes and it is seen that a good definition of the non-reflecting boundary conditions at the air inlet and flue outlet is of vital importance for accurate prediction of acoustic modes.

The prediction of acoustic modes represents a baseline validation, demonstrating the capability of a full Navier-Stokes method for predicting acoustic modes. This will be employed to assess a range of alternative attenuation methods based upon resonant devices such as Helmholtz resonators.

Keywords: Large eddy simulation, gas turbine, combustion instability, acoustics

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