Large eddy simulation of the response of turbulent non-premixed flame to acoustic perturbation

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Combustion instability is a major challenge in the development of low-emission advanced gas turbine. The mechanism of combustion instability in practical combustion devices involves very complex interactions between acoustic, combustion and hydrodynamic. In the present study, the effects of inflow perturbations on the turbulent swirling non-premixed $C_{12}H_{23}$-air flame in a combustor are investigated via fully compressible Large Eddy simulation (LES). Subgrid turbulence is modelled by the Wall-adapting local eddy-viscosity (WALE) sub-grid model and Dynamic Thicken flame model is applied to handle turbulence-combustion interaction. The Navier-Stokes characteristic boundary condition (NSCBC) method is used to handle acoustic reflection at the boundary. A reduced two-step kerosene-air chemical reaction scheme is used to describe chemical reaction. The inlet wave modulation method is used to imposing velocity perturbation with a moderate frequency (160 Hz) in either the fuel stream or the air stream. When acoustic perturbation is imposed in the air stream, the swirl number fluctuation is significantly affected by the inlet velocity perturbation. The flow field oscillates significantly. When swirl number increases, the size of center recirculation zone and the flame angle becomes larger. The interaction between flame and wall is affected significantly. Different outcome has been found when acoustic perturbation is imposed in the fuel stream. The heat release fluctuation is directly affected by the variation of the mass flow rate of fuel. The couple between heat release fluctuation and acoustic become stronger. However, the swirl number does not change too much because the azimuthal velocity only changes slightly. The acoustic perturbation only affects the flame length significantly, but has small effect on the flame angle.