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Flame Volume Prediction and Validation for Lean Blowout of Gas Turbine Combustor

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Abstract : The operation of aero engines has a critical importance in the vicinity of lean blowout (LBO) limits. Lefebvre's model of LBO based on empirical correlation has been extended to flame volume concept by the authors. The flame volume takes into account the effects of geometric configuration, the complex spatial interaction of mixing, turbulence, heat transfer and combustion processes inside the gas turbine combustion chamber. For these reasons, flame volume based LBO predictions are more accurate. Although LBO prediction accuracy has improved, it poses a challenge associated with Vf estimation in real gas turbine combustors. This work extends the approach of flame volume prediction previously based on fuel iterative approximation with cold flow simulations to reactive flow simulations. Flame volume for 11 combustor configurations has been simulated and validated against experimental data. To make prediction methodology robust as required in the preliminary design stage, reactive flow simulations were carried out with the combination of probability density function (PDF) and discrete phase model (DPM) in FLUENT 15.0. The criterion for flame identification was defined. Two important parameters i.e. critical injection diameter (Dp,crit) and critical temperature (Tcrit) were identified, and their influence on reactive flow simulation was studied for Vf estimation. Obtained results exhibit ±15% error in Vf estimation with experimental data.

Keywords : CFD, combustion, gas turbine combustor, lean blowout
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