Dynamics of Premixed Flames Subjected to Helical Disturbances
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Introduction

Motivation
Lean, premixed combustion used for reducing unfavorable emissions is prone to combustion instability
• Unfavorable feedback between unsteady heat release rate oscillations and natural acoustic modes causes high amplitude pressure oscillations, damages hardware, increases costs and emissions.
• Key mechanism
  • Velocity oscillations → Focus
  • Fuel/air ratio oscillations

Swirl Combustors
Swirling flows aid in flame stabilization
• High turbulence content (turbulent flame speed enhancement)
• Recirculation features of flow
Swirling flows possess complex unsteady features such as helical instabilities.
• Helical mode decomposition (integer modes)
• Flow instabilities are vortical in nature
• Helical modes are excited during instabilities

Objectives
• Acoustics excites helical disturbances which then excite the flame
  Acoustic waveform
  \[ f(x) = \sum_{n=1}^{N} C_n e^{i \omega n x} \]
  Pressure Anti-node Pressure Node
• Experiments
  • Asymmetric helical modes dominate flame response.
  • How conclusive are these observations?
  • Most conclusions from planar diagnostics
  • Out of plane physics unavailable
  • MOTs a 3D model for flame response

Modeling objectives
1. Determine how different helical modes affect flame response.
2. Determine importance of mean flame shape
3. Do these answers change for high amplitude effects?

Analytic Flame Description
Thin-flame assumption (level-set)
Inverted conical flame

Linear Dynamics

Non-Linear Dynamics

Conclusions

References/ Publications