Project 028(B) Area-4: Development of LES Combustion Models to Characterize Jet-Fuel Effects on Combustion Stabilization and Ignition

Stanford University, United Technology Research Center

Project Lead Investigator

Matthias Ihme
Assistant Professor
Department of Mechanical Engineering
Stanford University
488 Escondido Mall, Building 500, Room 500A, Stanford, CA 94304
650-724-3730
mihme@stanford.edu

University Participants

Stanford University

- P.I.(s): Matthias Ihme, Assistant Professor
- FAA Award Number: 13-C-AJFE-SU-005
- Period of Performance: 12/01/2014-11/30/2015
- Task(s):
    - Develop and extend large-eddy simulation (LES) combustion models to describe fuel-effects on spray evaporation, combustion, and flame stabilization
    - Perform large-eddy simulation of referee-rig combustor to provide assessment of fuel-effects on lean-blow-out conditions

Project Funding Level

FAA Amount Awarded: $100,000
Cost Share Amount: $100,000
Source of Cost Share: Mechanical Engineering Department, UTRC, Stanford University, and Professor Ihme non-sponsored account

Investigation Team

Matthias Ihme, Assistant Professor
- Tasks: principal investigator, oversees project progress, coordination with research teams from other FAA-NJFCP subject areas, presentation of research findings

Lucas Esclapez: Postdoctoral students
- Tasks: LES model development; performs simulations of referee-rig combustor, analysis of simulation results, assistance in preparing biweekly presentations

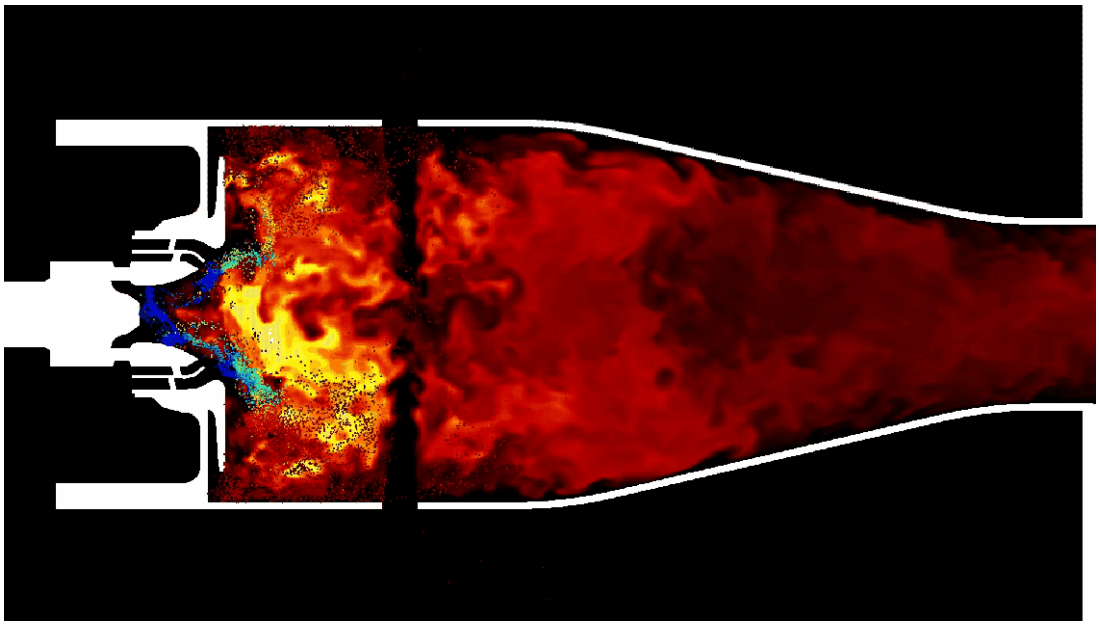
Vaidya Sankaran: PhD, UTRC
- Provided baseline mesh for referee-rig combustor

Project Overview, Approach, and Accomplishments

The objective of this research is the development of LES modeling capabilities that enable the prediction of fuel effects on lean-blow-out conditions in aviation gas-turbine combustors. Primary modeling efforts focus on the development and implementation of essential submodel components for the representation of liquid fuel droplet distribution, effusive cooling, fuel evaporation, combustion, and flame stabilization. A complementary effort addresses the development of simulation procedures to examine lean-blow-out conditions to numerically examine fuel-effects on LBO.

Main accomplishments regarding the combustion modeling include:

- Formulation and implementation of combustion submodels for FAA-transportation fuels Cat A2 and C5
- Implementation of effusive boundary conditions to describe air-flow split through primary and secondary injector
- Extension of FPV-combustion model to describe combustion of prevaporized fuel Cat A2 and C5
- Integration of referee-rig combustor geometry into LES-solver
- Formulation and prescription of boundary conditions for air-mass flow rate, spray-droplet distribution from empirical SMD-scaling
- Conduct simulations to assess flame-structure, assessment of model performance, and essential model sensitivities
- Formulation of protocol to examine static and dynamic LBO-conditions; develop metric to quantify LBO-behavior



Simulation of referee combustor rig, showing instantaneous temperature field and spray droplet distribution.

Publications

- Characterization of Fuel Effects on Lean Blowout in Gas Turbine Combustors, L. Esclapez, P. C. Ma, M. Naik, and M. Ihme, accepted for presentation at AIAA SciTech Meeting, San Diego, 2016.