Department of the Navy SBIR/STTR Transition Program

Pending SYSCOM Review

Topic # N17A-T002

Physics-based Computationally Efficient Spray Combustion Models for LES of Multiphase Reacting Flows

CFD Research Corporation

WHO

SYSCOM: NAVAIR

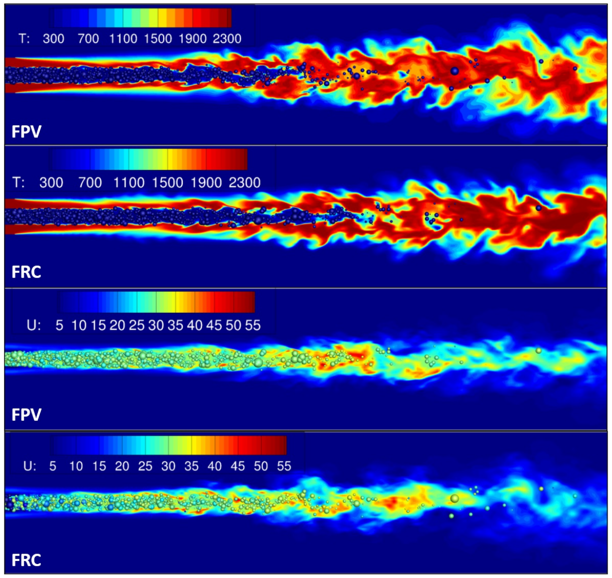
Sponsoring Program: PMA-265

Transition Target:

TPOC:

Other transition opportunities: Navy, Air Force, Army, major aero engine primes including GE Aviation, Pratt & Whitney, Williams International, and Rolls Royce

Notes: Image compares flamelet-progress variable (FPV) and finite rate chemistry (FRC) based simulations of a piloted acetone spray flame experiment



WHAT

Operational Need and Improvement: Combustion chemistry remains one of the most computationally expensive components of aircraft engine simulations, and real fuel spray-combustion introduces complex physics which can be difficult to model. The Flamelet Progress Variable approach is a well-established method for drastically increasing computational efficiency for gas-phase combustion, and extending the approach to multiphase flow enables these benefits within spray-combustion applications. Flamelet methods have a relatively narrow range of applicability, however this can be alleviated via the Pareto-Efficient Combustion approach which dynamically switches between chemistry models in a way that balances accuracy and cost.

Specifications Required: Investigate and develop a model for spray-flame simulations including effects of multicomponent aviation fuels, preferential evaporation effects, and complex combustor geometries. Verify and validate the computationally efficient spray combustion model using experimental data sets. Demonstrate the model as APIs in reacting flow codes relevant to current and future Navy engine applications of interest.

Technology Developed: The multiphase flamelet approach has been developed as a software API for coupling with CFD solvers, and is demonstrated within a fully coupled density-based compressible flow solver. A standalone software package for generating flamelet tables, for use in both gas-phase and multiphase simulations, has also been developed.

Warfighter Value: Accurate simulations of real fuel spray combustion is crucial for predicting performance, emissions, and stability in gas turbines and augmentors. The accuracy of the spray combustion models used in CFD simulations have a strong impact on the reliability of these predictions, and their computational efficiency is a limiting factor in cost and trade studies. This software tool can speed up computations by orders of magnitude over traditional methods, and incorporates the complex physics determined to play an important role in the targeted applications.

WHEN

Contract Number: N68335-19-C-0177 **Ending on:** March 29, 2022

Milestone	Risk Level	Measure of Success	Ending TRL	Date
Develop gas-phase capabilities	Low	Incorporate flamelet progress variable method into LES solver	2	July 2020
Create models for spray phenomena	Med	Demonstrate analytical models comparable to detailed CFD	2	July 2021
Develop multi-phase capabilities	Med	Couple flamelet method to spray evaporation source terms	3	September 2021
Validate on Canonical Problem	Low	Accurately simulate piloted acetone spray flame	4	December 2021
Option: Validate on Realistic Problem	Med	Accurately simulate swirl-stabilized spray-combustion experiments using aviation fuels	4	July 2021
Option: Integrate API into additional code base	Low	Interface API to Navy-relevant CFD solver, verifying and validating the implementation	5	March 2023

HOW

Projected Business Model: CFD Research Corporation plans to transition this technology to DoD government labs and primes via licensing of our software tools. CFD Research provides also provides on-site software training and consulting services, i.e. using the software to analyze candidate engine configurations and perform parametric studies on behalf of third parties,

Company Objectives: CFD Research Corporation specializes in engineering simulations, advanced prototypes, and innovative designs for aerospace, defense, life sciences, materials, energy, and other industries. Using our software and experimental capabilities, we develop new hardware concepts, innovative designs, and superior solutions for our customers with lower risk, reduced costs, and less time.

Potential Commercial Applications: The models have broad appeal for any spray-combustion applications, including power generation, commercial aircraft, internal combustion engines, and industrial furnaces and boilers. The API can be licensed to private industry and commercial CFD software vendors for integration into their own solvers, and can be tailored for specific applications as needed.

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