

Innovation

SBIR Topic Number:
AF05-194

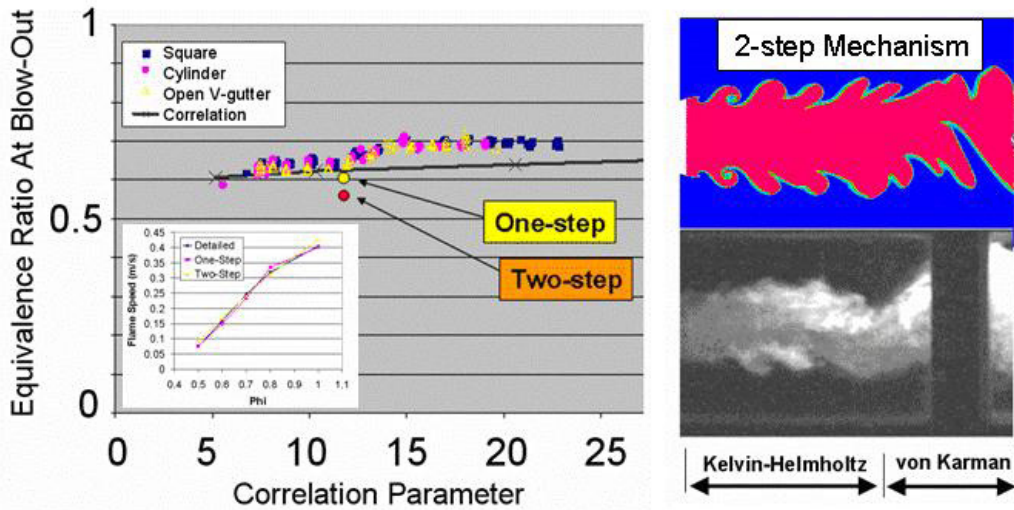
SBIR Title:
Improved Modeling Tools
for High Speed Reacting
Flows

Contract Number:
FA8650-06-C-2610

SBIR Company Name:
CFD Research Corporation
Huntsville, AL

Technical Project Office:
AFRL Propulsion
Directorate, Wright-
Patterson AFB, OH

This Air Force SBIR/STTR Innovation Story is an example of Air Force supported SBIR/STTR technology that met topic requirements and has outstanding potential for Air Force and DoD.



Comparison of Blow-Out Equivalence Ratio and Flame Structure for V-Gutter Flameholder; Predictions Using Global Mechanisms Generated With Firefly Are Close to Experimental

New Method for Automation and Optimization of the Curve Fit Kinetics Generating Process

- The Air Force needs accurate modeling of combustion kinetics for Computational Fluid Dynamics (CFD) analysis of high-speed reacting flows
- The Firefly software has an intuitive Graphical User Interface (GUI), allowing the user to generate reduced global kinetic mechanisms with speed and accuracy
- Using SBIR funding, CFD Research Corporation (CFDRC) developed a software package, called Firefly, to efficiently and accurately generate global mechanisms from detailed mechanisms
- This software package is useful in the cost-effective design and analysis of military propulsion systems (such as scramjet, ramjet, gas turbine), or of any other system involving advanced chemical kinetics

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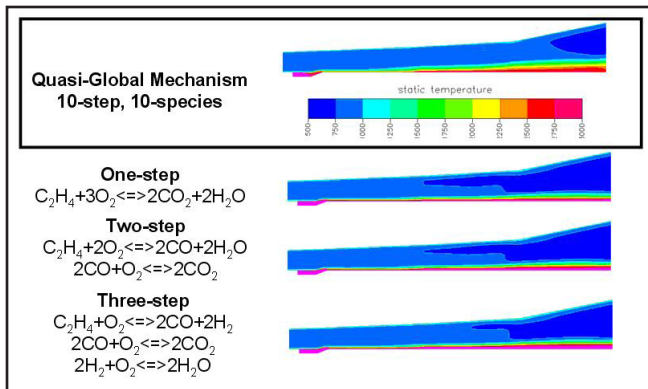
Air Force Requirement

Computational Fluid Dynamics (CFD) simulations are a necessary prerequisite to correctly predict a variety of combustion phenomena encountered in typical aerospace propulsion systems, such as combustion efficiency, blow-out, instabilities, flashback, emissions, etc. However, current run-time and convergence requirements limit practical CFD combustion simulations to simplified chemistry. Several methods currently exist to generate reduced kinetic mechanisms, but these methods are tedious, computationally expensive, or produce mechanisms that do not have a standard format that can easily be used in standard CFD codes. In addition, the resultant mechanisms often lack sufficient accuracy compared to detailed mechanisms.

The Air Force needs improved approaches to efficiently and accurately generate reduced mechanisms for CFD analysis of high speed reacting flows.

SBIR Technology

Under this SBIR project, CFD Research Corporation (CFDRC) developed a software package, called Firefly, to efficiently and accurately generate global mechanisms from detailed mechanisms. The ability to include accurate reduced reaction mechanisms allows for simulation turn-around times to be on par with the current computational capabilities while providing the accuracy of the detailed kinetic mechanism.



Comparison of Static Temperature Contours in a Scramjet Combustor (Predictions made using global mechanisms generated by Firefly are close to those made using a more detailed quasi-global mechanism)

Firefly allows the user to tune single- or multi-step kinetic mechanisms to detailed mechanisms that include hundreds of species and reactions. The Arrhenius coefficients of the

global mechanism are optimized to match some relevant phenomena of interest (such as ignition delay, extinction limits, pollutant emissions, and flame speed) over a specified range of conditions.

The Firefly software has an intuitive Graphical User Interface (GUI), allowing the user to generate global mechanisms with speed and accuracy.

The ability of Firefly to generate accurate global mechanisms has been demonstrated by performing validation CFD simulations (scramjet, augmentor flame holder).

Potential Air Force Application

The software is intended to be a preprocessor for CFD calculations, allowing the combustion engineer to dynamically and efficiently generate global mechanisms that are accurate for the conditions of interest.

The Firefly software package is useful in the cost-effective design and analysis of scramjet, ramjet, gas turbine, and other military propulsion systems. The ability to achieve fast turn-around times in CFD simulations, with the added assurance of accurate results, is now possible.

Firefly can also generate global kinetic mechanisms for CFD analysis of commercial combustion systems in the burner and boiler, chemical processing, aerospace and automotive industries. It can also be used as a stand-alone chemical kinetics calculator.

Company Impact

This SBIR project provided CFDRC (www.cfdrc.com) with the capability to better model combustion kinetics in CFD analyses and the opportunity to increase its commercialization base. Several government agencies and companies have expressed interest in CFDRC's Firefly technology, including NASA, General Electric, ATK Thiokol, Williams International, Solar Turbines, and Aerojet.

CFDRC specializes in engineering simulations and innovative designs. Physics-based (multi-scale, multi-fidelity, multi-disciplinary) simulations facilitate objective decisions in the development of new concepts, designs, and operations of engineering equipment and systems.



U.S. AIR FORCE

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