Air Force SBIR/STTR

Transition

Air Force SBIR/STTR Transition Story

SBIR Topic Number:
AF06-177

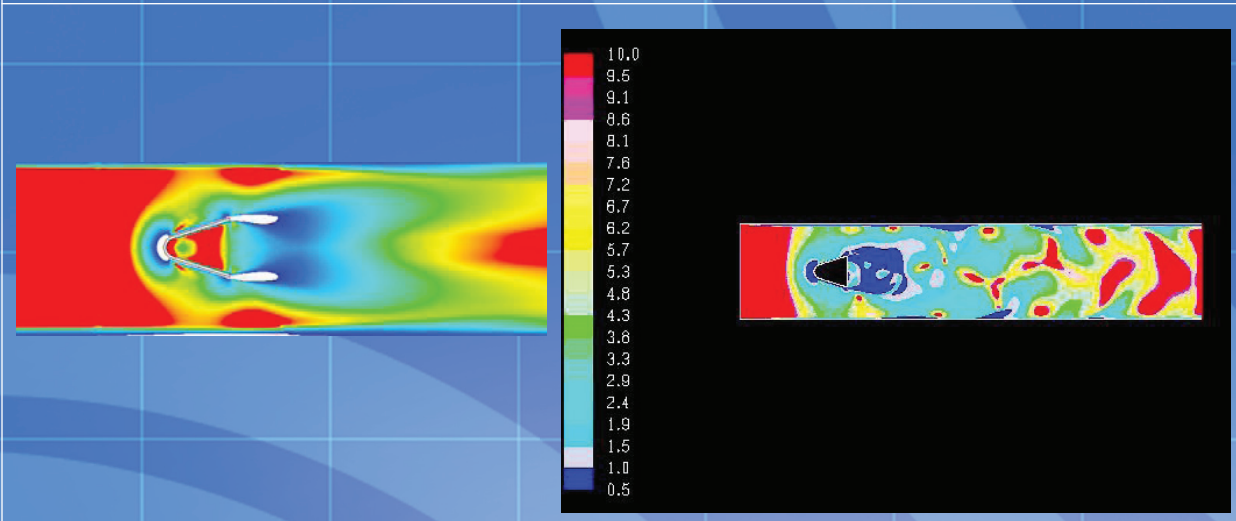
SBIR Title:
Reduced-Order Stability Model for Combustion Systems

Contract Number:
FA8650-07-C-2729

SBIR Company Name:
Creare Inc.,
Hanover, NH

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

An example of Air Force supported SBIR/STTR technology that has been transitioned into an Air Force or other DoD system or subsystem or used by Air Force test ranges and facilities or maintenance depots.



Left: Mean Damköhler Number Field for a 2D Rig Geometry. On average, the flame cannot survive in the white regions due to strain-induced extinction. Right: Snapshot of Time-Resolved Damköhler Number Field for 2D Rig Geometry. Creare's blowout modeling tool is implemented within ANSYS-Fluent.

Reduced Order Combustion Stability Modeling

- Combustion stability is critical to the operational performance of numerous gas turbine engines
- Creare developed a design tool for predicting stability (i.e., blowout) that provides designers with a significantly improved predictive capability relative to existing empirical correlations
- The software tool allows researchers and designers to calculate local Damköhler (Da) number fields within the familiar Fluent-ANSYS software environment; the Da information can then be analyzed to predict stability
- This tool has the potential to decrease development time and cost for future designs while improving performance
- The tool has been transitioned to the Air Force Research Laboratory and to Creare's industrial partners, including a major engine original equipment manufacturer (OEM) for the U.S. military

Commercialization Pilot Program Series

AFRL/RZ10-0616

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SBIR Requirement

Combustion stability is critical to the operational performance of numerous gas turbine engines. Current predictive tools for augmentor performance and static stability (i.e., blowout) are based on decades-old empirical correlations that do not provide reliable estimates for advanced augmentor designs. In these correlations, blowout is controlled by competition between global flow and chemical timescales. These timescales can be used to form a Damköhler (Da) number, and the correlations can be generally classified as global Da correlations.

Recent advances in computational fluid dynamics (CFD) and advanced combustion diagnostics have provided new insight into the fundamental processes that occur in combustor flows. Reacting-flow CFD has yet to mature to a level where it can be practically applied as a design tool for this problem.

SBIR Technology

During this SBIR program, Creare developed a design tool for predicting blowout that provides designers with a significantly improved predictive capability relative to existing empirical correlations. The approach uses modern computational techniques to calculate flow and chemical timescales and does not directly rely on empiricism. These timescales are used to calculate the local Da number in the stabilizing region of the flame. The local Da number field is then analyzed to predict blowout.

Creare developed its blowout prediction methodology into a software tool that can be used by augmentor designers within a standard commercial CFD code. The tool has been developed as a Scheme interface for ANSYS-FLUENT®. The tool includes embedded user-defined functions (UDFs) for compiling flow statistics from CFD simulations and capability for inputting chemical timescale data calculated offline using a separate chemical kinetics solver. In the second year of the SBIR project, Creare published the tool and it was demonstrated both on a combustion rig geometry and a real engine geometry.

Transition Impact

The software tool allows researchers and designers to calculate local Da number fields within the familiar Fluent-ANSYS software environment. The Da information can then be analyzed to predict stability. The tool has been transitioned to the Air Force Research Laboratory and to Creare's industrial partners, including a major engine original equipment manufacturer (OEM) for the U.S. military.

Technology derived from this project is in the form of design tools for predicting combustion stability. This tool has the potential to decrease development time and cost for future designs while improving performance. This technology may be applied to other complex combustion systems, such as gas turbine combustors for power generation, or advanced propulsion systems such as scramjets. In addition to design tools, this research program has provided new discussion and insight into the mechanisms that control augmentor blowout.

Company Impact

"This technology enabled Creare to expand our previous work in combustion into augmentors, a new area of focus for us," states Dr. Darin A. Knaus, Creare's principal investigator for this SBIR project. "Combustion is an active area of research because as jet engine performance and requirements increase, realizing optimal combustion performance is increasingly challenging. This project opened the door to several related R&D projects at Creare and was the genesis for several combustion technologies under development at Creare."

U.S. AIR FORCE

SBIR/STTR

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