Air Force SBIR/STTR

Innovation

Air Force SBIR/STTR Innovation Story

SBIR Topic Number:
AF05-301

SBIR Title:
Chemical Quick Quench Probe for Engine Emissions Measurements

Contract Number:
FA9101-06-C-0194

SBIR Company Name:
Aerodyne Research, Inc.
Billerica, MA

Technical Project Office:
Arnold Engineering Development Center,
Arnold AFB, TN

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.

Chemical Quick-Quench Probe for Aircraft Engine Emissions Measurements

- The Air Force requires an innovative probe design that can minimize any probe effects on trace gas emissions measurements
- A gas sampling probe that quenches chemical reactions by using supersonic expansion and helium dilution was developed by Aerodyne Research, Inc. (ARI) for the Arnold Engineering Development Center (AEDC)
- The Chemical Quick-Quench (CQQ) probe has demonstrated its potential to be employed as a standard method for the Air Force to measure the performance of afterburning military engines
- The enhanced capability of the CQQ probe to accurately characterize engine emissions will enable the Air Force to better determine the emissions performance of operational aircraft

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Air Force Requirement

The objective of this SBIR project was to develop a reliable method for quenching chemistry in aircraft exhaust sampling systems, thus minimizing the measurement errors incurred by chemical conversion during sampling. The chemical composition of the exhaust streams of aircraft engines (augmented and non-augmented) and combustors are required for the determination of combustion efficiency and for understanding pollutant formation.

Typically, extractive sampling is used to measure aircraft emissions; however, these measurements are biased by chemistry that can occur as the gas sample travels through the probe and sample transfer line from the combustor/engine-exit plane to the analyzer. The composition that actually reaches the analyzer can be different than that which enters the probe. The Air Force requires an innovative probe design that can minimize any probe effects on trace gas emissions measurements.

SBIR Technology

A gas sampling probe that quenches chemical reactions by using supersonic expansion and helium dilution was developed by Aerodyne Research, Inc. (ARI) for the Arnold Engineering Development Center (AEDC). The probe was designed through rounds of computational modeling and laboratory testing, and was subsequently manufactured and then tested at the University of Tennessee Space Institute (UTSI) behind a J85-GE turbojet engine.

The experimental test results demonstrated that the Chemical Quick-Quench (CQQ) probe suppressed the oxidation of carbon monoxide (CO) inside the probe system and preserved more CO at afterburning conditions. In addition, the CQQ probe prevented hydrocarbons from being partially-oxidized to form CO at idle powers, thus measuring more hydrocarbons and less CO at that low power condition.

The CQQ probe also suppressed nitrogen dioxide (NO2) to nitric oxide (NO) conversion through all engine power settings. These data strongly support the conclusion that the CQQ probe is able to quench unwanted chemical reactions inside the probe, not only under afterburning conditions but for all engine power levels.

Potential Air Force Application

The CQQ probe has demonstrated its potential to be employed as a standard method for the Air Force to measure the performance of afterburning military engines. In particular, measuring the combustion efficiency of afterburning engines has been difficult due to the challenge of measuring CO in the reacting plume. By quenching chemistry in the sampling process, the CQQ probe allows the accurate measurement of CO and more reliable determination of the afterburning engine performance. Through the use of the CQQ probe, the Air Force can now evaluate different engine technologies more effectively and make more sound decisions in procurement as well as in operation.

In addition, the environmental impact of military aircraft has been receiving increased attention in recent years. Although individual military engines do not need to be certified for emissions performance prior to sale, airbases as a whole may become subject to operational restrictions as part of the efforts to improve the regional air quality. This is a current pressing concern for the Department of Defense (DoD). The enhanced capability of the CQQ probe to accurately characterize engine emissions — including CO and hydrocarbons (HCs) at idle, NO/NO2 across all powers, and CO at afterburning — will enable the Air Force to better determine the emissions performance of operational aircraft.

Company Impact

ARI is active in developing instruments for the measurement of emissions and of trace gases in the atmosphere. In addition, ARI focuses a significant research effort on measuring and assessing aircraft emissions performance in a wide variety of research programs.

This SBIR-developed technology provides ARI with an opportunity to enhance and extend its capabilities in evaluating aircraft emission performance to include afterburning engines, and to better assess emissions at all power conditions for both military and commercial engines. ARI can now commercialize the CQQ probe by the manufacture and sales of CQQ probe packages to the aircraft engine development community, and by providing contract services for reliable engine emission measurements.

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