FUELS RESEARCH - COMBUSTION EFFECTS OVERVIEW

John B. Haggard, Jr.
National Aeronautics and Space Administration
Lewis Research Center

Fuels combustion research is conducted (1) to isolate and identify those physical and chemical properties of fuels that affect aviation gas-turbine combustion; (2) to determine combustion sensitivity to variations in particular fuel properties; and (3) to identify advanced combustion concepts and subcomponents that could lessen the effect of using broadened-property fuels.

Fuels combustion research needs have been identified through various analytical and experimental assessments of the effect of broadened-property fuels on gas-turbine combustors. Activities to address those needs may fall into three categories: fundamentals, combustion concepts, and long-term fuel effects.

Combustion fundamentals encompasses analytical and experimental efforts where unrestricted approaches to simulating combustors are pursued in an attempt to discern broad general results. Five thrusts are identified: (1) chemical kinetics, wherein experiments and analyses are performed to identify rate-controlling mechanisms; (2) soot formation and oxidation, wherein mechanisms of soot formation and subsequent burnout are identified; (3) flame radiation, in which radiant heat flux to combustor liners is measured and soot concentration profiles are obtained from spectral radiant intensities; (4) thermodynamic properties, wherein analyses and subsequent computer programs are developed to provide data required for using broadened-property fuels; and (5) partial oxidation, in which techniques such as catalytic reaction are used to partially oxidize the fuel so as to reduce soot-forming tendencies.

In the second category, combustion concepts, programs are directed toward evolving advanced technology aimed at optimizing combustion performance with broadened-property fuels. Five thrusts are identified: (1) performance studies of unmodified, inservice combustors to define potential problems and to provide a baseline of broadened-property-fuel effects; (2) burning zone studies, in which several advanced combustion concepts are evaluated with alternative fuels; (3) fuel injection studies, in which the spatial and size distributions of fuel sprays are evaluated with broadened-property fuels for several types of fuel injectors; (4) liner concepts, in which advanced liner coatings, advanced designs, and redistributed cooling-air flows are studied; and (5) fuels safety studies, in which the characteristics of fuel systems and combustor performance are studied with special fuels designed to reduce fires during a crash.

The last category is long-term fuel effects. These activities, which will be started once the best approaches to using broadened-property fuels are identified, are concerned primarily with durability evaluations modeled to accelerate long-term cyclic effects.

Three of the six papers in this session are concerned with combustion fundamentals. They present analytical and experimental studies of fuel property effects on soot formation and oxidation. Dr. Ruth of Exxon Research and Engineering Co. reviews a multiyear effort, funded by DOE, that examines fuel property effects on soot formation in strongly backmixed combustion. Professor Prado of the Massachusetts Institute of Technology reviews recent work of the Chemical Engineering Department on soot formation and burnout in flames. Dr. Moses of Southwest Research Institute reviews a recently completed effort, funded by NASA, that examined molecular structure effects on soot formation in combustors.

The remaining three session papers focus on a variety of combustion concepts. Professor Skifstad of Purdue University reviews the progress of a NASA-funded grant aimed at identifying fuel property effects on the spray characteristics of various classes of fuel injectors. Mr. Schmidt of the NASA Lewis Aircraft Safety Office reviews an FAA - NASA-funded study with Pratt & Whitney Aircraft Group on the compatibility of an antimisting fuel with fuel system and combustor operation. Finally, Mr. Humenik of the NASA Lewis Fuels Branch reviews some in-house studies on the sensitivities of tubular combustors to broadened-property fuels and summarizes the results of flame-tube tests.

AIRCRAFT RESEARCH AND TECHNOLOGY FOR FUTURE FUELS