NUMERICAL STUDY OF LOW EMISSION GAS TURBINE COMBUSTOR CONCEPTS

Final Technical Report

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EXECUTIVE SUMMARY

To further reduce pollutant emissions, such as CO, NOx, UHCs, etc., in the next few decades, innovative concepts of gas turbine combustors must be developed. Several concepts, such as the LPP (Lean-Premixed-Prevaporized), RQL (Rich-Burn Quick-Quench Lean-Burn), and LDI (Lean-Direct-Injection), have been under study for many years. To fully realize the potential of these concepts, several improvements, such as inlet geometry, air swirler, aerothermochemistry control, fuel preparation, fuel injection and injector design, etc., must be made, which can be studied through the experimental method and/or the numerical technique. The purpose of this proposal is to use the CFD technique to study, and hence, to guide the design process for low emission gas turbine combustors. A total of 13 technical papers have been (or will be) published.

ACHIEVEMENTS

During the course of this research, many technical papers have been published and are listed below for the consideration as the project final technical report:

1. Penko, P. F., Kundu, K. P., and Yang, S. L., 1999, "Application of a Reynolds-Stress Turbulence Model to Gas Turbine Combustor Calculations," AIAA Paper 99-0485, 37th AIAA Aerospace Sciences Meeting and Exhibit, Reno, Nevada, January 11-14.
2. Penko, P. F., Kundu, K. P., and Yang, S. L., 1999, "Modeling Axial Flow Combustors Using KIVA-3 with Reynolds-Stress Turbulence and a Jet-A Kinetics Mechanism," 9th Engine Combustion Multidimensional Modeling User's Group Meeting at the SAE Congress, Feb. 28, Detroit, Michigan.
3. Yang, S. L., Peschke, B. D., and Tacina, R., 1999, "Numerical Simulation of A Lean Direct Injection Combustor Using A Reynolds Stress Closure Model," Proceedings of the 4th International Conference on Internal Combustion Engines: Experiments and Modeling, ICE99, pp. 73-80, Capri-Naples, Italy, Sept. 12-16, 1999.
4. Kundu, K. P. Penko, P.F., and Yang, S. L., 1998, "Simplified Jet-A/Air Combustion Mechanisms for Calculation of NOx Emissions," AIAA Paper 98-3986, 34th AIAA/ASME/SAE/ASEE Joint Propulsion Conference, Cleveland, Ohio, July 13-15.
5. Penko, P.F., Kundu, K.P., Siow, Y.K., and Yang, S. L., "A Kinetic Mechanism for Calculation of Pollutant Species in Jet-A Combustion," AIAA Paper 2000-3035, 35th AIAA Intersociety Energy Conversion Engineering Conference, 24-28 July 2000, Las Vegas, Nevada.
6. Kundu, K. P. Penko, P.F., and Yang, S. L., 1998, "Reduced Reaction Mechanisms for Numerical Calculations in Combustion of Hydrocarbon Fuels," AIAA Paper 98-0803, 36th AIAA Aerospace Sciences Meeting and Exhibit, Reno, Nevada, January 12-15.
7. Siow, Y. S. and Yang, S. L., "3-D Analysis of Jet-A Combustion with a Kinetic Mechanism for Pollutant Species," AIAA Paper 2001-3422, 37th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, Salt Lake City, UT, July 8-11, 2001.
8. Teo, C. Y., Siow, Y. S., and Yang, S. L., "Flowfield Study of LDI Combustor with Discrete-Jet Swirler Using Re-Stress Model," AIAA Paper 2001-3424, 37th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, Salt Lake City, UT, July 8-11, 2001.
9. Siow, Y.K., Yang, S. L., R. Tacina, and Penko, P.F., "Design and Determination of Radial Air Swirler Blade Lengths Using CFD," AIAA Paper 2001-0975, 39th AIAA Aerospace Science Meeting and Exhibit, 8-11 January 2001, Reno, Nevada.
10. Yang, S. L., Y. K. Siow, Peschke, B. D., and Tacina, R., "Numerical Study of Nonreacting Gas Turbine Combustor Swirl Flow Using Reynolds Stress Modeling," ASME Journal of Engineering for Gas Turbines and Power (in press).
11. Urip, E., Yang, S. L., and Marek, C.J., " An Excel Program for Spray Jet in Crossflow," to be published as a NASA TM.

12. Yang, S. L., Teo, C. Y., Y. K. Siow, Tacina, R., and Penko, P. F., "Numerical Study of LDI Combustor with Discrete-Jet Swirlers Using Re-Stress Model," submitted to the ASME Journal of Engineering for Gas Turbines and Power (under review).

13. Yang, S. L., Teo, C. Y., Y. K. Siow, Tacina, R., and Penko, P. F., "CFD Study of Discrete Jet LDI Combustor Using Re-Stress Turbulence Model," NASA TM (under review).