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Technical Quarterly Progress Report
Advanced Gas Turbine Systems Research
Cooperative Agreement DE-FC21-92MC29061

October 1, 1998 – December 31, 1998

SUMMARY

Major Accomplishments by AGTSR during this reporting period are highlighted below and amplified in later sections of this report:

Administrative

- AGTSR submitted FY99 program continuation request to DOE-FETC for \$4M
- AGTSR submitted program and workshop information to the Collaborative Advanced Gas Turbine (CAGT) initiative
- AGTSR distributed research accomplishment summaries to DOE-FETC in the areas of combustion, aero-heat transfer, and materials
- AGTSR reviewed and cleared research papers with the IRB from Arizona State, Cornell, Wisconsin, Minnesota, Pittsburgh, Clemson, Texas and Georgia Tech
- AGTSR prepared background material for DOE-FETC on three technology workshops for distribution at the DOE-ATS conference in Washington, DC
- AGTSR coordinated two recommendations for reputable firms to conduct an economic impact analysis in support of new DOE gas turbine initiatives
- AGTSR released letters announcing the short-list winners/ non-winners from the 98RFP solicitation
- AGTSR updated fact sheet for 1999 and announced four upcoming workshops via the SCIES web page



- AGTSR distributed information to EPRI on research successes, active university projects, and workshop offerings in 1999
- AGTSR continued to conduct telephone debriefings to non-winning PI's from the 98RFP solicitation
- AGTSR distributed completed quarterly progress report assessments to the IRB experts in the various technology areas
- AGTSR provided information to GE-Evandale on the active combustion control research at Georgia Tech
- AGTSR provided information to AlliedSignal and Wright-Pat Air Force Base on Connecticut's latest short-listed proposal pertaining to NDE of thermal barrier coatings

Research

- AGTSR submitted final technical reports from Georgia Tech - one on coatings and the other on active combustion control - to the IRB for review and evaluation
- AGTSR coordinated the format, presentation and review of 28 university research posters for the ATS Annual Review Meeting in November, 1998
- AGTSR published a research summary paper at the ATS Annual Review pertaining to the university consortium's activities
- AGTSR published and presented a paper on the status of ATS catalytic combustion R&D at the RTA/NATO Gas Turbine Combustion Symposium, October 12-16, 1998 in Lisbon, Portugal
- IRB approved a 12-month add-on request from Penn State University to conduct an added research task in their multistage unsteady aerodynamics project
- AGTSR reviewed a research extension white paper from Clemson University with the IRB to conduct an added task pertaining to their mist/steam cooling research project

- AGTSR coordinated new research topics with the IRB and select universities to facilitate R&D roadmapping needs at the Aero-Heat Transfer III workshop in Austin, TX
- AGTSR distributed FY97 research progress reports to DOE and the IRB
- AGTSR solicited new R&D topics from the IRB experts for the 1999 RFP

Workshops/Education

- AGTSR presented status-update briefing at the ATS Annual Review in November, 1998
- AGTSR organized a special forum on aeroderivative gas turbines for ISABE XIV in Italy, September, 1999
- AGTSR co-organized an aero film cooling session with the University of North Dakota for IGTI99 in June, 1999
- AGTSR fellow from Caltech presented combustion dynamics short course (part II) at Pratt & Whitney/UTRC
- AGTSR announced three technology workshops: TBC Specialty Workshop, Aero-Heat Transfer III, and Combustion VI
- AGTSR assisted DOE-FETC and Energetics in planning a gas turbine visioning workshop in Austin, TX, February, 1999
- AGTSR released application packets for the industrial internship and faculty fellowship programs
- AGTSR participated in the microturbine technology summit offered by DOE-HQ's in December, 1998
- AGTSR was invited to present a TBC highlight paper at the TMS-High Temperature Coatings session in San Diego, CA, March, 1999

Membership

- The University of Virginia becomes a new AGTSR performing member
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MEMBERSHIP

During this reporting period, the University of Virginia (UV) became a new performing member of AGTSR. The contact at UV is Dr. James Groves who has experience in unique vapor deposition technologies for coatings on advanced gas turbine blades. AGTSR membership is currently at 96 schools, representing 37 states.

The AGTSR Industry Review Board (IRB) currently consists of 8 companies, with the latest two additions occurring in the first quarter of 1998, Southern Company Services (non-voting member) and AlliedSignal Engine Company (voting member).

In 1993 through 1998, AGTSR received cost-sharing contributions of \$25,000 from each of the IRB voting members. The eight IRB companies are complemented by EPRI and GRI who continue to act as utility and industrial gas turbine advisors for AGTSR. Invoices for the 1999 IRB membership fee will be released in January 1999. As of this date all the IRB companies have paid their annual membership fee for 1998. Parker Hannifin is an associate member of AGTSR and have paid their non-voting dues in advance through 1999.

1993-through-1997 SUBCONTRACT PROGRESS

All ten of the FY93 projects have been completed and final reports have been received and processed by AGTSR.

Twelve of the thirteen FY94 AGTSR research projects have finished and completed their final report commitment. The remaining FY94 project is from UC Irvine (combustion). The PI is Professor Samuelsen. The UC Irvine final report is expected to be submitted to AGTSR by the end of January 1999.

All FY96 and FY97 Semi-Annual Progress Reports have been received by AGTSR and were distributed to both the IRB and DOE. These progress reports were all accompanied by assessment forms for our industry contacts to complete. The next set of progress reports are due by the end of February 1998.

Per the 98-01 RFP, the IRB short-listed ten proposals (5 in combustion, 3 in aero-heat transfer, and 2 in materials). New awards from the 98RFP are expected to be initiated in February 1999, pending FY99 funding availability.

Completed assessment forms covering research evaluations in the areas of aero-heat transfer, materials, and combustion were consolidated during this quarter and distributed to the IRB and DOE. Copies of these completed assessments will be returned to the IRB members and DOE on at least a semi-annual basis.

Final reports currently being reviewed by the IRB include two projects from Georgia Tech (combustion-Zinn and materials-Carter).

AGTSR's COMBUSTION WORKSHOP VI

AGTSR Combustion Workshop VI will be co-hosted with VPI in Blacksburg, VA. The meeting date is set for April 18-21, 1999, and the co-hosts are Professors Uri Vandsburger and Will Saunders who have an ongoing AGTSR project in the area of active combustion control. AGTSR and VPI have detailed a tentative agenda for the Workshop which includes a strategic planning session to support the needs of DOE-FETC in preparing their position paper for the next generation gas turbine. Both DOE and Energetics are in the process of reviewing the agenda to possibly change its format to better facilitate the R&D roadmapping needs of DOE-FETC. The DOE contact for this combustion workshop is Geo Richards. Jack Eisenhauer is the contact at Energetics. The first announcement for this workshop was released in September 1998. Registration material should be forthcoming by the end of January 1999. For additional information, please contact AGTSR at 864-656-2267.

TBC SPECIALTY WORKSHOP

For AGTSR, Professors Clarke, Evans and Levi of UC-Santa Barbara (UCSB) organized a 2 1/2-day workshop to bring together the AGTSR TBC university contractors, the AGTSR industrial partners, and selected attendees from other academic, industrial and government organizations. The dates for the workshop were January 6-8, 1999 at UCSB. It is expected that nearly 70 people will be participating. The first half-day of the Workshop is dedicated to strategic planning with the focus on TBC research needed to support the next generation of gas turbine systems. Several topics were recommended with industry-university leads designated for each topic area to draft white papers expanding on the technical content and R&D needs. These white papers will be reviewed during the IGTI99 Expo in Indianapolis. The proceedings for this Workshop should be distributed by the end of February 1999. For additional information, please contact AGTSR at 864-656-2267 or Professor Levi at UCSB, 805-893-2381/levic@engineering.ucsb.edu.

AGTSR's AERO-HEAT TRANSFER III WORKSHOP

The third AGTSR Aero-Heat Transfer Workshop will be co-hosted with UT-Austin (UTA) and Virginia Tech (VT) at the Barton Creek Conference Resort in Austin, TX, February 10-12, 1999. The contact persons are Professor Bogard of UTA and Professor Thole of VT (who recently transferred from the University of Wisconsin-Madison). The workshop will include a review of both aerodynamic and heat transfer R&D with AGTSR/ATS university and industrial partners. On February 10, a strategic planning session will be held to discuss future aero-heat transfer R&D as influenced by evolving DOE gas turbine initiatives for the post-ATS era. On February 11-12, three industry panels will be held on turbine cooling, aerodynamics, and endwall flows to define the critical generic R&D needs pertaining to particular company initiatives and/or DOE future gas turbine initiatives as described in the DOE-FETC position paper. The first announcement for the workshop was released in September 1998, and registration material was released in December 1998. For additional information, please contact Dan Fant or Karen Thole at 864-656-2267, or 540-231-7192, respectively.

DOE's VISIONING WORKSHOP

This workshop is by invitation and is being organized by DOE-FETC, Energetics, and SCIES. It takes place on February 9-10, 1999 at the Barton Creek Conference Center in Austin, TX. The first set of invitations was mailed out in December 1998 to approximately 60 people, and the second mailing is expected to be released in mid-January 1999. The meeting will bring together a group of experts from industry, academia, and government organizations that will meet for 1 ½ days to discuss a strategic vision for future gas turbine power systems. The purpose of this workshop is to define the most promising near and long-term gas turbine power systems, and the market applications for these systems. Research and development roadmapping needs will also be discussed during the workshop. The workshop registrants will also receive a draft position paper written by DOE-FETC which describes the next generation gas turbine power systems being considered for the post-ATS era. This position paper will form the basis for discussion at the visioning workshop. For further information, please call Ms. Abbie Layne of DOE-FETC (304-285-4603) or SCIES at 864-656-2267.

DOE's MICROTURBINE TECHNOLOGY SUMMIT

AGTSR participated in the DOE microturbine summit in Orlando, FL on December 7-8, 1998 in the Orlando Airport Marriott Hotel. DOE's long-range goal is moving toward the development of ultra-efficient, low cost microturbines that may be deployed in a variety of applications ranging from residences to industrial processes. The meeting kicked off with marketing and technical talks from DOE, EPRI, and GRI along with OEM talks from Capstone, NREC, AlliedSignal, Rolls-Royce Allison, Teledyne, and GE. The R&D breakout sessions were facilitated by Energetics and focused on the market, regulatory, and technical barriers to near term deployment of microturbine systems, and the science and engineering barriers to the development of ultra-high efficiency machines. For additional information on the outcome of this workshop, please contact Debbie Haught in DOE-HQ's at 202-586-2211. If interested in obtaining hardcopies of the presentation materials from the workshop, please call AGTSR at 864-656-2267.

ATS ANNUAL REVIEW MEETING

AGTSR participated in the ATS Annual Review Meeting in Washington, DC, November 2-4, 1998. AGTSR gave an overview presentation highlighting the status of the university consortium and board approval for a new central energy facility at Clemson which features a Solar Turbines' gas turbine power plant. An AGTSR update paper was written for this meeting which described specific R&D accomplishments associated with university research projects in the areas of combustion, aero-heat transfer, and materials. A university poster session was also presented showcasing the latest results and research plans for 1999 - 28 research posters were displayed at the meeting. If interested in obtaining a copy of the AGTSR update paper, please contact AGTSR at 864-656-2267. For a copy of the proceedings, please contact Ms. Judi Abraham of Conference Management Associates (CMA) at 703-754-0066.

AGTSR PARTICIPATES IN IGTI'99

AGTSR will be co-chairing a session at IGTI in Indianapolis in June 1999 with the Professor Forrest Ames of the University of North Dakota. The session is on experimental investigations of aero film-cooling flows with

a total of 5-6 papers being presented. AGTSR will also be presenting a paper on ATS catalytic combustion R&D with the University of Maryland, UC Berkeley, Solar Turbines, Siemens-Westinghouse, and PCI. In addition, as part of the TBC Workshop at UCSB, draft white papers generated on various TBC research issues to support the next generation of gas turbines will be discussed during an ad-hoc meeting in conjunction with the IGTI99. Further, AGTSR will likely participate in a booth display as part of the ATS DOE-FETC/ ORNL advertisement. For more information on AGTSR's role in IGTI'99, please contact Dan Fant at 864-656-2267.

AGTSR CONSIDERS TWO ADD-ON RESEARCH PROJECTS

During the last quarter, Professor Lakshminarayana of Penn State submitted an add-on proposal to AGTSR requesting an additional \$50K to enhance his current research on multistage compressor modeling and experiments. The added task related directly to the parent program and focused on resolving in detail the unsteady flow in the endwall region. The majority of the IRB recommended it for support and AGTSR plans to fund the add-on for a 12-month period in early 1999. In this quarter, Professor Wang of Clemson submitted an 11-month/ \$50K add-on request to extend his mist cooling research project to include impingement cooling on flat and curved surfaces. This add-on request is currently being reviewed by the IRB and a decision to support the project extension should be made by the end of next quarter. If interested in obtaining more information on the results of these two research projects, please contact AGTSR at 864-656-2267.

AGTSR INVITED TO THE 1999 TMS ANNUAL MEETING

AGTSR was invited to present a paper at the TMS Meeting in San Diego, CA, February 28 – March 4, 1999. The paper is titled TBC Research Highlights in the AGTSR Consortium. The paper will be presented in the high temperature coatings III – thermal barrier coatings II session. The talk will focus on highlighting the active research projects being supported by AGTSR in the area of thermal barrier coatings. The issues to be discussed include TBC bond strength and stress measurements, chemical and mechanical instabilities at TBC interfaces, advanced coating techniques, NDI for TBC's, and life prediction. In addition, a summary of the Metallic Coatings Specialty Workshop at Stevens Institute in April 1998 and the TBC Specialty Workshop at UCSB in January 1999 will be provided. The co-organizer for the TMS Meeting and co-chair for this particular session is Professor Hampikian of Georgia Tech. For additional information on the meeting, please contact Dr. Hampikian at 404-894-2845 or

AGTSR at 864-656-2267.

AGTSR TO COORDINATE MARKETING STUDY FOR DOE

DOE-FETC has requested that AGTSR coordinate an economic impact analysis (EIA) on the gas turbine power generation outlook through 2010. The emphasis is on pre-competitive R&D needed in industry, monies spent on gas turbine R&D within government and industry, and the future market and R&D forecast of gas turbines and its impact on the U.S. domestic economy. Per the recommendation of IGTI and Gas Turbine World, AGTSR sought out two candidates to conduct the EIA study. They are Forecast International in Newtown, CT and The Windsor Group in Boston, MA. AGTSR is currently reviewing both qualifications packages and by the end of January, 1999 will make a recommendation to DOE-FETC on the best candidate. The project is anticipated to be for 5-6 months being completed during the summer of 1999. For additional information on this EIA study, please contact AGTSR at 864-656-2267.

NEW AWARDS FROM 98RFP

In the fall of 1998, the Industry Review Board (IRB) short-listed 10 research proposals from the 98RFP. The distribution was 5 in combustion, 3 in aero-heat transfer, and 2 in materials. AGTSR anticipates funding as many short-listed proposals as consistent with available funding. All decisions on funding will be coordinated with the FETC COR. The funding scenario for the 98RFP should be finalized by the end of next quarter. For additional information on the status of the short-listed proposals, please contact AGTSR at 864-656-2267.

AGTSR'S EDUCATIONAL PROGRAMS

In December 1998, AGTSR distributed the 1999 application brochures for the industrial internship and faculty fellowship programs. For 1998, AGTSR placed 11 interns at ATS company sites. The final summary reports for these interns should be distributed to DOE and the IRB by the end of next quarter. For 1999, DOE-FETC mandated that interns will be limited to U.S. citizens and PRA's only. Also, for 1999, the interns pay will be pro-rated at \$450, \$550, and \$650 per week for graduating seniors, MS, and PhD students, respectively. In 1998, AGTSR selected five faculty fellows. Of the five fellows, two have already completed their programs (Professor Roy/ASU at Solar, and Professor

Gore/Purdue at Allison). The other three will be continuing throughout part of 1999. In addition, Professor Culick of CalTech presented the second part of a four part short course on active combustion control to P&W/UTRC in December 1998. The third part of his course is tentatively scheduled for February-March 1999 at UTRC. For 1999, AGTSR anticipates supporting 10-15 new interns and 4-5 new fellows.

Miscellaneous Activities

AGTSR plans to release its tenth newsletter in March 1999 in which the results of several new workshops and research-educational projects may be highlighted.

AGTSR recently presented an invited paper for the RTA/ NATO Gas Turbine Engine Combustion, Emissions and Alternative Fuels symposium in Lisbon, Portugal, on October 12-16, 1998. The title of the paper was the "Status of Catalytic Combustion R&D in the ATS Program." The paper will also be published in the proceedings which should be available for distribution in the spring of 1999.

AGTSR co-organized a special forum for the XIV International Society for Air Breathing Engines (ISABE) Symposium in Florence, Italy, September 5-10, 1999. The focus of the forum is on the use of Aero-Derivative Land-Based Gas Turbines for future power generation. In the fall of 1998, AGTSR received commitments from several organizations to participate in the forum, namely: GE, P&W, MHI, Solar Turbines, Rolls Royce, NASA-Lewis, and DOD-Air Force.

AGTSR solicited new research topics from the IRB for its seventh RFP (99-01) solicitation. The 99RFP is expected to be released by the end of March 1999 with proposals due by mid-June.

Fiscal year 1999 is a critical year for AGTSR as DOE-FETC and SCIES are planning strategically for various gas turbine initiatives in the next decade and evaluating the continued role of a university research consortium to help support those initiatives. In that respect, several technology workshops are being offered by AGTSR in FY99 to provide input to the gas turbine R&D roadmapping needs of DOE-FETC. As a result, AGTSR believes that future RFP's should target post-ATS research activity.
