TECHNICAL PROGRESS REPORT

Quarterly

Reporting Period start date: October 1, 2002

Reporting Period end date: December 31, 2002

Principal Author: Dr. Lawrence P. Golan

Date report was issued (reissued) : May 2003

DOE Award No. DE-FC21-92MC29061

Submitting Organization:
South Carolina Institute for Energy Studies
Advanced Gas Turbine Systems Research Program
Clemson University Research Foundation
386-2 College Ave
Clemson, SC 29634-5712

DISCLAIMER*

“This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.”

Technical Quarterly Progress Report

Advanced Gas Turbine Systems Research
Cooperative Agreement DE-FC21-MC29061

October 1, 2002 to December 31, 2002

ABSTRACT:

The activities of the Advanced Gas Turbine Systems Research (AGTSR) program for the reporting period October 1, 2002 to December 31, 2002 are described in this quarterly report. No new membership, workshops, research projects, internships, faculty fellowships or special studies were initiated during this reporting period. Contract completion is set for June 30, 2003. During the report period, six research progress reports were received (3 final reports and 3 semi-annual reports). The University of Central Florida contract SR080 was terminated during this period, as UCF was unable to secure research facilities. AGTSR now projects that it will under spend DOE obligated funds by approximately 340-350K\$.

TABLE OF CONTENTS:

- Executive Summary:
 - Introduction
- Experimental
- Results and Discussion
- Conclusion
- References
- Attachments

Technical Quarterly Progress Report
Advanced Gas Turbine Systems Research
Cooperative Agreement DE-FC21-92MC29061
October 1, 2002 to December 31, 2002

EXECUTIVE SUMMARY:

The AGTSR program is now functioning under a time extension approved by DOE/NETL. The AGTSR completion date is set for June 30, 2003. During the time extension period, no new activities will be added to AGTSR. Research work will continue as the university subcontractors continue/complete their work. SCIES will provide the necessary oversight to assure progress is made. No new Membership, Workshops, Research Projects, Internships, Faculty Fellows or Special Studies will be initiated under AGTSR.

AGTSR received 6 Progress Reports during this reporting period. Three of the reports were final reports.

- Improved Performance and Durability in Gas Turbines Through Airfoil Clocking and Hot Streak Management, PI—Eric Sandgren, Virginia Commonwealth University, SR083
- Active Control of Combustion Instabilities in Low NO_x Gas Turbines, PI—Ben Zinn, Georgia Tech, SR075
- Interaction of Steam/Air Mixtures with Turbine Airfoil Alloys and Coatings, PI—Fred S. Pettit, University of Pittsburgh, SR077

The remaining three reports are semi-annual progress reports. The three final reports have shown the following:

- clocking of hot streaks provides a modest improvement in efficiency, whereas airfoil clocking alone provides a much more significant improvement
- significant progress was made in developing capabilities to predict conditions under which combustion instabilities occur including amplitude. In addition, an advanced adaptive control system was developed that can rapidly and effectively suppress combustion oscillations
- a better understanding of how high temperature and pressure steam effect the oxidation of materials for use in advanced gas turbines was developed

INTRODUCTION

The AGTSR program was initiated to develop the base technology necessary for improving efficiency and reducing emission in land based gas turbines. The fuel of

choice for these power turbines is natural gas. The technology areas of interest are combustion, materials, and aero-heat transfer.

EXPERIMENTAL:

No experimental data to include from the administration of this program. At the request of the AGTSR COR, weekly research progress reports are being sent to NETL

RESULTS AND DISCUSSION:

Program Administration

- The AGTSR/ATS Quarterly Technical Report for the reporting period of July to September 2002 was submitted to NETL on October 30, 2002. The report was submitted via hard copy and disk.
- Normal administrative functions required to monitor existing AGTSR contracts continued through the reporting period.
- The University of Central Florida research program (SR080) has been terminated. UCF completed only one year of the potential three-year effort. The reason for termination was that UCF was unable to secure the necessary facilities to conduct the program. Termination was suggested by the UCF PI and accepted by SCIES.

Research

- Attachment I contains a listing of the AGTSR technical progress reports released during this reporting period.
- No new activities have been added.

AGTSR Financial Status

The decision by the University of Central Florida to terminate their AGTSR subcontract (SR080) at the completion of one year of a projected three-year contract unobligates significant AGTSR research dollars. As can be seen on Attachment II, UCF spent approximately \$75K of the 6

CONCLUSION:

This quarter ended with continued success in the administration of the Advanced Gas Turbine Systems Research Program. At the request of the AGTSR COR, weekly research progress reports are being sent to NETL. Individual conclusions on those projects are included at that time.

REFERENCES:

All references to specific projects are included at the end of each projects specific progress report. At the request of the AGTSR COR, weekly research progress reports are being sent to NETL. Individual reference listings on those projects are included at that time.

ATTACHMENT I

AGTSR Progress Reports Received

October 1, 2002 — December 31, 2002

Aero-Heat Transfer	Virginia Commonwealth University Final Report October 2002 Subcontract #00-01-SR083 Paper Version Only	Improved Performance and Durability in Gas Turbines Through Airfoil Clocking and Hot Streak Management <i>PI – Eric Sandgren</i>
Aero-Heat Transfer	Louisiana State University Semi-Annual Report Mar.-Aug. 2002 Subcontract #02-01-SR089 LINK TO REPORT	Internal Cooling In Leading-and Trailing-Edge Passages with Rotation and Buoyancy <i>PI – Sumanta Acharya</i>
Aero-Heat Transfer	University of Texas, Austin Semi-Annual Report 3/1/02-9/31/02 Subcontract #01-01-SR092 Paper Version Only	Attenuation of Hot Streaks and Interaction of Hot Streaks with the Nozzle Guide Vane and Endwall <i>PI – Dave Bogard</i>
Combustion	Georgia Tech Final Report October 2002 Subcontract #99-01-SR075 LINK TO REPORT	Active Control of Combustion Instabilities in Low NOx Gas Turbines <i>PI – Ben Zinn</i>
Materials	University of Pittsburgh Final Report December 2002 Subcontract #99-01-SR077 LINK TO REPORT	Interaction of Steam/Air Mixtures with Turbine Airfoil Alloys and Coatings <i>PI – Fred S. Pettit</i>
Materials	University of Connecticut Semi-Annual Report 2/1/02-8/31/02 Subcontract #01-01-SR091 LINK TO REPORT	Thermal Barrier Coatings and Metallic Coatings with Improved Durability <i>PI – Maurice Gell</i>

Attachment II

7-Jan-03

Financial Status of AGTSR Subcontracts
RFP93, RFP94, RFP95, RFP6, 97 Interns,
RFP97, RFP98, RFP99, RFP00

				a	b	c	d	e		
		Term	End	Requested						
	Institution	in years	Date	AGTSR	Obligated	Expenditures	a-c	b-c		
	RFP93			Funding	to Date	to:	Balance	Balance		
c	SR007	Cal-Berkeley	3	3/31/97	\$518.20	\$518.20	3/97f	\$518.20	\$0.00	\$0.00
c	SR008	Vanderbilt	3	12/31/96	\$862.60	\$862.60	12/96f	\$862.60	\$0.00	\$0.00
c	SR009	Purdue	3	2/27/97	\$801.69	\$801.69	2/97f	\$801.69	\$0.00	\$0.00
c	SR010	Lehigh	3	12/31/96	\$748.39	\$748.39	12/96f	\$748.39	\$0.00	\$0.00
c	SR011	Texas A&M	3	2/28/97	\$585.88	\$585.88	2/97f	\$585.88	\$0.00	\$0.00
c	SR012	Penn State	3	12/31/96	\$628.81	\$628.81	12/97f	\$628.81	\$0.00	\$0.00
c	SR013	Virginia Tech*	3	3/31/97	\$462.01	\$462.01	3/97f	\$462.01	\$0.00	\$0.00
c	SR014	Brigham Young	4	12/31/97	\$1,040.99	\$1,040.99	12/97f	\$1,040.99	\$0.00	\$0.00
c	SR015	LSU	3	2/28/97	\$478.18	\$478.18	2/97f	\$478.18	\$0.00	\$0.00
c	SR016	Clarkson	2	3/31/96	\$522.80	\$522.80	3/96f	\$522.80	\$0.00	\$0.00
	Subtotal			\$6,649.55	\$6,649.55	\$6,649.55	\$0.00	\$0.00		
	RFP94									
c	SR017	MIT	1	8/31/95	\$156.46	\$156.46	7/95f	\$156.46	\$0.00	\$0.00
c	SR018	Cornell	2	8/31/96	\$165.70	\$165.70	8/96f	\$165.70	\$0.00	\$0.00
c	SR019	Purdue	3	2/28/98	\$675.69	\$675.69	4/98f	\$675.69	\$0.00	\$0.00
c	SR020	Cal-Irvine	3	03/31/98	\$529.47	\$529.47	3/98f	\$529.47	\$0.00	\$0.00
c	SR021	Minnesota	3	12/31/97	\$670.27	\$670.27	12/97f	\$670.27	\$0.00	\$0.00
c	SR022	Central Fla	1	8/18/95	\$73.84	\$73.84	8/95f	\$73.84	\$0.00	\$0.00
c	SR023	Carnegie Mellon	3	8/31/97	\$537.37	\$537.37	7/97f	\$537.37	\$0.00	\$0.00
c	SR024	Clemson	3	8/31/97	\$601.19	\$601.19	8/97f	\$601.19	\$0.00	\$0.00
c	SR025	Wyoming	1	7/15/95	\$69.26	\$69.26	7/95f	\$69.26	\$0.00	\$0.00
c	SR026	Michigan State	1	8/31/95	\$178.42	\$178.42	7/95f	\$178.42	\$0.00	\$0.00
c	SR027	Georgia Tech	3	4/15/98	\$432.48	\$432.48	4/98f	\$432.48	\$0.00	\$0.00
c	SR028	Maryland	3	4/16/98	\$573.14	\$573.14	4/98f	\$573.14	\$0.00	\$0.00
c	SR029	Oklahoma	2	6/30/97	\$297.71	\$297.71	6/97f	\$297.71	\$0.00	\$0.00
	Subtotal			\$4,961.00	\$4,961.00	\$4,961.00	\$0.00	\$0.00		
	RFP95									
c	SR030	Conn	3.5	2/28/99	\$500.00	\$500.00	2/99f	\$500.00	\$0.00	\$0.00
c	SR031	Georgia Tech	3	8/31/98	\$571.52	\$571.52	8/98f	\$571.52	\$0.00	\$0.00
c	SR032	Penn State	3	2/28/99	\$600.63	\$600.63	1/99f	\$600.63	\$0.00	\$0.00
c	SR033	Arizona State	4	1/31/00	\$327.70	\$327.70	1/00f	\$327.70	\$0.00	\$0.00
c	SR034	Clemson	4	2/29/00	\$538.04	\$538.04	2/00f	\$538.04	\$0.00	\$0.00
c	SR035	Conn	1	5/22/97	\$88.48	\$88.48	5/97f	\$88.48	\$0.00	\$0.00
c	SR036	Penn State	3	09/30/00	\$450.00	\$450.00	9/00f	\$450.00	\$0.00	\$0.00
c	SR037	Syracuse	2	2/28/98	\$170.97	\$170.97	2/98f	\$170.97	\$0.00	\$0.00
c	SR038	MIT	1	8/31/96	\$151.79	\$151.79	8/96f	\$151.79	\$0.00	\$0.00
c	SR039	Central Fla	2	3/31/98	\$178.21	\$178.21	3/98f	\$178.21	\$0.00	\$0.00
c	SR040	Michigan State	1	12/31/96	\$140.00	\$140.00	12/96f	\$140.00	\$0.00	\$0.00
c	SR041	Wyoming	0.25	8/31/96	\$5.50	\$5.50	10/96f	\$5.50	\$0.00	\$0.00
	Subtotal			\$3,722.84	\$3,722.84	\$3,722.84	\$0.00	\$0.00		
	RFP96									
c	SR042	Cleveland State	3	12/12/00	\$313.68	\$313.68	12/00f	\$311.23	\$2.45	\$2.45
c	SR043	Wisconsin	3	6/12/00	\$370.56	\$370.56	6/00f	\$370.56	\$0.00	\$0.00
c	SR044	Purdue	2	5/12/00	\$204.07	\$204.07	5/00f	\$204.07	\$0.00	\$0.00
c	SR045	MIT	3	12/15/00	\$276.98	\$276.98	12/00f	\$276.11	\$0.87	\$0.87
c	SR046	Pittsburgh	3	6/12/00	\$500.10	\$500.10	6/00f	\$500.10	\$0.00	\$0.00
c	SR047	Northwestern	4	6/12/01	\$545.01	\$545.01	03/01f	\$545.01	\$0.00	\$0.00
T	SR048	California/Davis	3	06/12/98	\$17.98	\$17.98	1/98f	\$17.98	\$0.00	\$0.00
c	SR049	Cornell	3	06/12/00	\$594.22	\$594.22	6/00f	\$594.22	\$0.00	\$0.00
c	SR050	Penn State	3	6/12/00	\$317.81	\$317.81	8/99f	\$317.81	\$0.00	\$0.00
	Subtotal			\$3,140.41	\$3,140.41	\$3,137.09	\$3.32	\$3.32		
	1997 issued(interns & add-on)									
c	SR051	Univ of Buffalo		8/31/97	\$5.50	\$5.50	8/97f	\$5.50	\$0.00	\$0.00
c	SR052	USC		8/31/97	\$5.53	\$5.53	7/97f	\$5.52	\$0.01	\$0.01
c	SR053	Univ of Washing		9/15/97	\$6.65	\$6.65	9/97f	\$6.65	\$0.00	\$0.00
c	SR054	Purdue		8/31/97	\$5.50	\$5.50	8/97f	\$5.50	\$0.00	\$0.00
c	SR055	Univ of Arkansas		8/15/97	\$6.91	\$6.91	8/97f	\$6.91	\$0.00	\$0.00
c	SR056	Clarkson		12/31/98	\$10.46	\$10.46	11/98f	\$10.46	\$0.00	\$0.00
c	SR057	Univ of Cen Flori		8/31/97	\$5.50	\$5.50	8/97f	\$5.50	\$0.00	\$0.00
c	SR058	Michigan State		8/31/97	\$6.44	\$6.44	8/97f	\$6.44	\$0.00	\$0.00

c	SR059	Univ of Cal-Berk		8/31/97	\$8.25	\$8.25	8/97f	\$8.25	\$0.00	\$0.00
c	SR060	Virginia Polytech		8/31/97	\$11.00	\$11.00	8/97f	\$10.10	\$0.90	\$0.90
c	SR061	Cal-Berkeley		12/31/97	\$30.04	\$30.04	12/97f	\$30.04	\$0.00	\$0.00
		Subtotal			\$101.78	\$101.78		\$100.87	\$0.91	\$0.91
		1998(RFP97)								
c	SR062	Cal-Irvine	3	12/31/01	\$449.94	\$449.94	9/00f	\$449.94	\$0.00	\$0.00
c	SR063	CIT	3	06/30/01	\$390.20	\$390.20	1-Jun	\$390.20	\$0.00	\$0.00
c	SR064	Purdue	2	07/31/00	\$159.81	\$159.81	7/00f	\$158.23	\$1.58	\$1.58
c	SR065	VPI	3	08/30/01	\$603.39	\$603.39	1-Aug	\$603.09	\$0.30	\$0.30
c	SR066	Ga Tech	3	7/31/2002	\$441.00	\$441.00	7/2	\$433.99	\$7.01	\$7.01
c	SR067	U Central FL	2	06/30/00	\$198.62	\$198.62	6/00f	\$198.62	\$0.00	\$0.00
c	SR068	Cal-Santa Barba	3	01/31/01	\$599.94	\$599.94	12/00f	\$599.12	\$0.82	\$0.82
c	SR069	Purdue	3	07/31/01	\$427.94	\$427.94	07/01f	\$408.35	\$19.59	\$19.59
t	SR070	Car Mellon	3	01/31/00	\$374.44	\$374.44	1/00f	\$359.11	\$15.33	\$15.33
c	SR071	Minn	3	07/31/01	\$600.00	\$600.00	1-Jul	\$600.00	\$0.00	\$0.00
c	SR072	CIT(faculty spec)	1	08/31/99	\$25.00	\$25.00	8/99f	\$25.00	\$0.00	\$0.00
c	SR088	U Pittsburgh	1	07/31/01	\$185.53	\$185.53	07/01f	\$185.53	\$0.00	\$0.00
	seeSR070	Subtotal			\$4,455.81	\$4,455.81		\$4,411.18	\$44.63	\$44.63
		1999(RFP98)								
c	SR073	Univ of Conn	3	01/31/02	\$448.66	\$448.66	2-Jan	\$432.16	\$16.50	\$16.50
	SR074	UCBerkeley	3	11/30/2002	\$195.00	\$195.00	31-May	\$175.54	\$19.46	\$19.46
c	SR075	GaTech	3	7/31/2002	\$449.98	\$449.98	May-02	\$430.38	\$19.60	\$19.60
	SR076	Miss State Univ	3	2/28/2002	\$321.37	\$321.37	Jan-02	\$319.92	\$1.45	\$1.45
	SR077	Univ Pittsburgh	3	7/31/2002	\$430.64	\$430.64	Dec-01	\$369.11	\$61.53	\$61.53
c	SR078	PennStateUniv	3	3/31/2002	\$452.82	\$452.82	Mar-02	\$452.09	\$0.73	\$0.73
c	SR079	PennStateUniv	2	12/30/2001	\$427.25	\$427.25	Oct-01	\$427.14	\$0.11	\$0.11
c	SR080	Univ Central Fl	3	01/31/01	\$240.00	\$79.90	Jan-01	\$75.11	\$164.89	\$4.79
		subtotal			\$2,965.72	\$2,805.62		\$2,681.45	\$284.27	\$124.17
		2000(RFP99)								
	SR081	U Conn	3	1/31/2003	\$335.09	\$335.09	8/2	\$241.95	\$93.14	\$93.14
	SR082CS	TEES	2	8/31/2002	\$238.63	\$238.63	2-Jul	\$238.10	\$0.53	\$0.53
c	SR083	Virginia	2	7/31/2002	\$189.64	\$189.64	2-Jul	\$189.64	\$0.00	\$0.00
c	SR084CS	UCI	2	9/30/2002	\$135.94	\$135.94	2-Jul	\$135.94	\$0.00	\$0.00
	SR085CS	Purdue	2	2/28/2003	\$167.39	\$167.39	2-Nov	\$154.63	\$12.76	\$12.76
	SR086	N. Dakota	2.5	1/31/2003	\$193.16	\$193.16	2-Oct	\$186.12	\$7.04	\$7.04
	SR087	Washington	2	5/31/2002	\$104.31	\$104.31	4/2	\$102.86	\$1.45	\$1.45
		subtotal			\$1,364.16	\$1,364.16		\$1,249.24	\$114.92	\$114.92
		2001 (RFP00)								
	SR089	LSU	2	2/28/2003	\$171.74	\$171.74	2-Dec	\$145.03	\$26.71	\$26.71
c	SR090	Penn State	2	7/31/2002	\$192.87	\$192.87	07/02	\$172.47	\$20.40	\$20.40
	SR091	U Conn	2	8/1/2002	\$238.76	\$238.76	12/01	\$139.05	\$99.71	\$99.71
	SR092	U Texas at Austi	2	5/31/2003	\$242.70	\$242.70	10/02	\$234.13	\$8.57	\$8.57
c	SR093	UCSB	2	1/31/2003	\$299.68	\$299.68	07/02	\$299.68	\$0.00	\$0.00
c	SR094	TEES	2.5	2/28/2003	\$141.40	\$141.40	10/02	\$118.71	\$22.69	\$22.69
		subtotal			\$1,287.15	\$1,287.15		\$1,109.07	\$178.08	\$178.08
		GRAND TOTAL ALL			REQUESTED \$28,648.42	OBLIGATED \$28,488.32		EXPENDED \$28,022.29	REQUESTED \$626.13	OBLIGATED \$466.03
		DOE pay			\$28,106.46	\$27,946.36		\$27,493.62	\$612.84	\$452.74
		IRB pay			\$541.96	\$541.96		\$528.67	\$13.29	\$13.29

* refund rec'd 12/9/99

Notes: These were not research awards: SR041, SR051-SR060, SR072

Total portion of these funds that was for interns: \$91.74

Total portion of these funds that was for faculty fellows: \$25k

ATTACHMENT III--FINANCIAL STATUS REPORT

(Short Form)

(Follow Instructions on the back)

1. Federal Agency and Organizational Element to Which Report is Submitted U.S. DEPT. OF ENERGY MORGANTOWN, WV 26507-0880		2. Federal Grant or Other Identifying Number Assigned By Federal Agency DE-FC21-92MC29061		OMB Approval No 0348-0039	Page 	of pages
3. Recipient Organization (Name and complete address, including ZIP Code) Clemson University Research Foundation PO Box 946 Clemson, S.C. 29633-0946						
4. Employer Identification Number 57-0750000		5. Recipient Account Number or Identifying Number 3-34-7237 219-2000258		6. Final Report ☐ Yes ☒ No		7. Basis ☐ Cash ☒ Accrual
8. Funding/Grant Period (See Instructions) From: (Month, Day, Year) 10/15/92		To: (Month, Day, Year) 06/30/03		9. Period Covered by this Report From: (Month, Day, Year) 10/01/02		To: (Month, Day, Year) 12/31/02
10. Transactions:				I Previously Reported	II This Period	III Cumulative
a. Total outlays				33,479,372.20	71,088.25	33,550,460.45
b. Recipient share of outlays				365,465.28	86.24	365,551.52
c. Federal share of outlays				33,113,906.92	71,002.01	33,184,908.93
d. Total unliquidated obligations						985,890.07
e. Recipient share of unliquidated obligations						0.00
f. Federal share of unliquidated obligations						985,890.07
g. Total Federal share (Sum of lines c and f)						34,170,799.00
h. Total Federal funds authorized for this funding period						34,170,799.00
i. Unobligated balance of Federal funds (Line h minus line g)						0.00
11. Indirect Expense	a. Type of Rate (Place "X" in appropriate box) ☐ Provisional ☒ Predetermined ☐ Final ☐ Fixed					
	b. Rate DHHS 44%/46%		c. Base 30,817,074.40		d. Total 2,367,834.53	
				e. Federal 2,367,834.53		
12. Remarks: Attach any explanations deemed necessary or information required by Federal sponsoring agency in compliance with governing legislation. <div style="text-align: center; padding: 10px;"> All of December C/S are not yet available. The difference will be reported in the next Qtr. </div>						
13. Certification: I certify to the best of my knowledge and belief that this report is correct and complete and that all outlays and unliquidated obligations are for the purposes set forth in the award documents.						
Typed or Printed Name and Title Roberta H. Elrod, Grants & Contracts Manager Sponsored Programs Accounting & Administration				Telephone (Area code, number and extension) (864) 656-6151		
Signature of Authorized Certifying Official _____				Date Report Submitted <div style="text-align: center; padding-top: 10px;">February 05, 2003</div>		

As of 12/31/02
ATS has 985,890.07

Projected unspent DOE obligation