Advanced Turbine Systems Program Conceptual Design and Product Development

**Quarterly Report
August - October 1994**

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December 1994

Work Performed Under Contract No.: DE-AC21-93MC30247

**For
U.S. Department of Energy
Office of Fossil Energy
Morgantown Energy Technology Center
Morgantown, West Virginia**

MASTER

**By
Westinghouse Electric Corporation
Orlando, Florida**

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Office of Fossil Energy
Morgantown Energy Technology Center
P.O. Box 880
Morgantown, West Virginia 26507-0880

By
Westinghouse Electric Corporation
4400 Alafaya Trail
Orlando, Florida 32826

December 1994

QUARTERLY STATUS REPORT

Date: December 2, 1994
Report No. TPR-05
Reporting Period: August-October, 1994

CONTRACT TITLE AND NUMBER: Advanced Turbine Systems Program --
Conceptual Design and Product
Development DE-AC21-93MC30247

CONTRACTOR'S NAME: Westinghouse Electric Corporation
Power Generation Business Unit
4400 Alafaya Trail
Orlando, FL 32826-2399

CONTRACT PERIOD: August 5, 1993 to February 1, 1996

1.0 MANAGEMENT PLAN

The project management plan is being updated to reflect contract modifications.

2.0 NATIONAL ENERGY POLICY ACT (NEPA)

Two additional metallurgical test sites were surveyed for compliance with NEPA requirements. These surveys were in anticipation of the new work to be undertaken as part of increased Phase 2 work scope. The survey results indicated no additional environmental impacts. Therefore, no new permits or licenses are required.

The Clemson University environmental Health and Safety Report required by NEPA has been completed and sent to METC for approval prior to start of testing.

3.0 SELECTION OF NATURAL GAS-FIRED ADVANCED TURBINE SYSTEMS (GFATS)

ATS Thermal Cycles

A review of unconventional steam turbine configurations for combined cycle applications was carried out. The results indicated that there is a potential for improving the steam turbine efficiency, and hence the ATS combined cycle efficiency.

Topical Report

The draft of Topical Report on "Selection of Natural Gas-Fired Advanced Turbine System" was reviewed by METC. The suggested revisions are being incorporated into the final draft.

4.0 SELECTION OF COAL-FIRED ADVANCED TURBINE SYSTEMS (CFATS)

Task completed.

5.0 MARKET STUDY

The analytical software tools required to perform a competitive economic analysis of the ATS plant have been acquired. The analysis will employ a "screening curve" approach against alternative technologies, and will evaluate the levelized cost of electricity as a function of the capacity factor. The results will indicate how the ATS plant will perform competitively in peaking, intermediate and baseload applications. Potential sources of plant capital cost data to be used in the screening analysis have been identified.

6.0 SYSTEM DEFINITION AND ANALYSIS

The ATS gas turbine flange-to-flange conceptual design is proceeding. Preliminary engine cross-section lay-out was produced.

8.0 DESIGN AND TEST OF CRITICAL COMPONENTS

New ATS Research and Development Contracts

METS approved the additional Phase 2 Research and Development Projects. Work on some of these projects started in this quarter.

Effects of Blade Cooling Alternatives

An automated performance calculation system is being developed by Carnegie Mellon University (CMU) to assess the effects of different cooling media and cooling schemes on gas turbine cycle performance. Prepared a preliminary survey of recent technical literature on gas turbine blade cooling. Developed a computer code for calculating the temperature distributions over the inner and outer blade surfaces for a given expanding gas temperature and coolant inlet temperature and flow. The code performs integrated energy balance and conductive and convective heat transfer calculations for multiple connected blade sections. The code was tested against available data on the Phoenix stage 1 turbine blade.

An ASPEN based computer code was obtained for gas turbine combined cycle plant performance calculations. Studies are in progress to determine how the blade cooling process might be integrated into the performance calculation.

Single Crystal Blade Development

A milestone review of 501FA Rows 1 and 3 CMSX-4 single crystal cast blades was held in October. The Row 1 blades showed persistent "freckling" problem at the blade root area. Because the number of additional molds needed to achieve acceptable grain structure exceeded the number originally planned for the castability study, casting trials on the thick Row 1 blades will not be pursued further at this time. The thinner Row 3 blade castings exhibited positive grain results. However, in three castings core movement caused core exposure at the airfoil surface. A decision was made to cast one more mold of three blades. Platinum pins will be utilized to correct the core movement problem.

Ceramic Materials Development

Westinghouse representatives visited DuPont Lauxide Corporation to discuss SiC/Alumina material development status. This material has been selected for ATS turbine ring segment conceptual design studies. Discussions centered on design and manufacturing issues associated with incorporating SiC/Alumina ring segments into a W501 engine for field testing and evaluation.

Diffuser Air Extraction Study

The Clemson University test facility move to a new location was completed and the test facility is fully operational.

The vacuum-forming facility installation and upgrading has been completed. Vacuum forming of transition pieces was completed and finishing operations were started. The exhaust section fan fabrication was completed. Plenum construction and test model assembly was started.

A special test rig for measuring combustor basket discharge coefficient was fabricated. It will be used to measure the scaled-down dry low NOx plastic model combustor discharge coefficient. The 15 inexpensive "dummy" combustors will then be manufactured with equivalent discharge coefficients.

Computer codes are being written for automatic pressure measurements via the Scanivalve. The code will be used for wall pressure and five-hole probe pressure measurements. All pressure measuring locations have been identified and will be schematically displayed.

Solid modeling of the combustor support and cross-flame tube was completed.

The three-dimensional, body-fitted, orthogonal grid generation for the entire test section geometry has been completed. For calculation purposes the geometry was divided into the following four domains: pre-diffuser, upper and lower halves of the dump diffuser, and top hat area.

Griffith diffuser design was started.

Serpentine Channel Cooling Tests

Internal multi-pass turbine blade cooling configurations will be tested to optimize the cooling design and reduce cooling requirement. Plastic models of the cooling schemes are being manufactured. The models will be installed in the NASA Lewis test facility and tests will be performed to determine internal heat transfer coefficients and pressure drops.

PLANS FOR THE NEXT REPORTING PERIOD

Task

- 1.0 Issue updated Management Plan
- 2.0 Update the NEPA Topical Report, as required, to include additional candidate material testing sites.
- 3.0 Incorporate DOE/METC approval comments and issue the Task Topical Report.
- 5.0 Report on the marketing survey of the ATS based on data from Task 6.0.
- 6.0 Complete the conceptual design of the ATS combustion turbine.
- 8.0
- 8.5 Complete casting and evaluation of Row 3 single crystal blade castings.

- 8.8 Complete the basic air model test at Clemson University and initiate additional testing.
- 8.22 Complete plastic model manufacturing and initiate test at NASA Lewis on the multi-pass turbine blade cooling configurations.

R. L. Bannister
Program Manager

Attachments:

Request for Patent Clearance for Release of Contracted Research Documents (Form METC F 1332)
U. S. DOE, METC Contract Report Transmittal Checklist