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**Advanced Turbine Systems Program
Conceptual Design and Product Development**

**Quarterly Report
November 1993 - January 1994**

April 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

By
Westinghouse Electric Corporation
Orlando, Florida

MASTER

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QUARTERLY STATUS REPORT

Date: April 7, 1994
Report No. TPR-03
Reporting Period: November 1993 - January 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
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CONTRACT PERIOD: August 5, 1993 to February 3, 1995

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

A review of candidate advanced cycles was narrowed down to a base and three additional cycles. Account codes for capital cost and availability comparisons were prepared by Gilbert/Commonwealth as evaluation tools.

8.0 DESIGN AND TEST OF CRITICAL COMPONENTS

Westinghouse current activities and long term plans for advanced materials development were presented by Dr. Sastry Cheruvu at the Oak Ridge National Laboratory. The ATS program requirements for high temperature alloys, coatings and ceramic materials were defined.

The Materials/Manufacturing plan issued by the DOE Oak Ridge, Field Office was reviewed and comments returned.

The program to study the castability of single crystal ATS blades with CMSX-4 alloy with the blade configuration defined was initiated by Mr. Frank Roan, the Westinghouse Materials Engineer. The casting vendor selection process was started.

Rows one and two turbine ring segments have been selected by Westinghouse as appropriate components for ceramic materials development.

New ATS Research and Development Projects

A presentation was made at the end of November to DOE representative on additional ATS Program research and development projects. This presentation was repeated on December 14 at DOE METC, in Morgantown. Thirteen new projects were proposed in support of the ATS program goals. Four of the new projects addressed combustion system development, such as flow visualization optical diagnostics development investigation of combustion noise and catalytic combustion. Five projects dealt with turbine airfoil cooling, such as closed loop steam cooling, stator shroud cooling, trailing edge pressure surface cooling air ejection, serpentine channel cooling, and blade tip and ring segment cooling. The last four projects involved model turbine rig tests, active tip clearance control, brush seals, and stein seals. Cost estimates were made for the above projects and four additional ones. The additional projects were as follows:

CM-247 DS blade development, thermal barrier coating field testing, shrouded blade cooling, and last row turbine blade development.

ATS Thermal Cycles

Comparative cycle performance calculations were carried out by Westinghouse on different systems under consideration for the ATS gas fired plant. Performance estimates were made for approximately 50 different cases. The following major cycle categories were covered: combined cycle with enhancements, intercooled combined cycle, recuperated combined cycle, intercooled recuperated combined cycle, intercooled/aftercooled recuperative combined cycle, continuously cooled compressor combined cycle, reheat combustion turbine combined cycle, intercooled reheat recuperated combined cycle, thermo chemical recuperation with flue gas recirculation, and steam injected combustion turbine cycle.

A one day meeting was held to review the results of the cycle performance calculations. Both internal and external experts attended the meeting. Results of calculation on each cycle were discussed in some detail. Suggestions were made on how to enhance the ATS plant performance further in order to achieve the ATS Program goal of greater than 60% plant cycle efficiencies (on LHV basis). It was decided to carry out further calculations on the following four cycles:

ATS CANDIDATE CYCLES (a, b)

Baseline Cycle: ATS Combustion Turbine with a Steam Turbine having Inlet Steam conditions of 1800 psi/1100°F/1100°F

Recuperated Combined Cycle: ATS Combustion Turbine with a Steam Turbine having Inlet Steam Conditions of 1450 psi/1000°F/800°F

Reheat Combined Cycle: ATS Reheat Combustion Turbine with a Steam Turbine having Inlet Steam Conditions of 1800 psi/1100°F/1100°F

Thermochemical Recuperated Cycle: ATS Combustion Turbine with Flue Gas Recirculation and Flue Gas Turbine Cooling.

Notes:

- (a) The four candidate cycles have estimated efficiencies in excess of 60 percent.
- (b) Cycle and turbine enhancements include:
 - Rotor air cooler heat used for fuel preheating.
 - Closed loop steam cooling (except for the Thermochemical Recuperated Cycle).
 - Increased generator efficiency, single shaft configuration.
 - Bowed vanes in steam turbine.

Combustion Cylinder Model Tests (Subtask 8.8 - Diffuser Extraction Study)

Clemson University will conduct tests on a half-scale plastic model of a combustion cylinder with combustors and transitions in place to study the flow throughout the combustion cylinder. Originally the tests were to be carried out on a model of the 501F combustion cylinder. Subsequently it was decided to use the upgraded 501FA combustion cylinder. A visit was made to Clemson by Messrs. Ron Bannister and Ihor Diakunchak and, Dr. Bill Ryan to discuss progress on this project and to outline proposed additions to this program. The additional tests to include investigation of the effect on flow distribution inside the combustion cylinder of compressor exit swirl, flow shields around the combustor baskets, length of the "top hat" at the head end of the combustor baskets, modulation of the air by-pass valves, curved compressor exit diffuser, and ultra low NOx combustor baskets.

PLANS FOR THE NEXT REPORTING PERIOD

1.0 Update the Project Management Plan

- 2.0 Update the NEPA Topical Report to include additional candidate materials testing sites.
- 3.0 Selection of the best natural gas-fired combined cycle for ATS.
- 4.0 Study initiation to determine the degree of technical development needed for conversion of the selected gas fired ATS for efficient coal-fired operation.
- 6.0 Analysis of combustion turbine component studies.
- 8.0 Completion of the basic air model tests at Clemson University and creation of a plan to conduct additional related testing.

Several ATS initiatives are to be presented to METC by Westinghouse that could be studied under Task 8. Some of the topics to be discussed include: Advanced materials and coatings, thermochemical and partial oxidation cycles, and low NOx combustion concepts.

Paul W. Viscovich
Deputy Program Manager

DATE

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END