Report No. DE-FG02-85ER52118-5

RENSSELAER POLYTECHNIC INSTITUTE
Non-Profit Educational Institution
Troy, New York 12180-3590

DOE/ER/52118--5

DE91 001872

Technical Progress Report

Entitled

ARIES TOKAMAK REACTOR STUDY

for

USDOE Grant No. DE-FG02-85-ER52118

for the period

1 December 1989 through 30 November 1990

Submitted on behalf of

Don Steiner
Institute Professor

and

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Associate Professor

Department of Nuclear Engineering & Engineering Physics

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1. INTRODUCTION

This is a status report on technical progress relative to the tasks identified for the fifth year of Grant No. DE-FG02-85-ER52118. The ARIES tokamak reactor study is a multi-institutional effort to develop several visions of the tokamak (ARIES-I, II and III) as an attractive fusion reactor with enhanced economic, safety, and environmental features. The ARIES study is being coordinated by UCLA and involves a number of institutions, including RPI. The RPI group has been pursuing the following areas of research in the context of the ARIES-I design effort: 1) MHD equilibrium and stability analyses; 2) plasma-edge modeling and 3) blanket materials issues. Progress in these areas is summarized herein.

2. MHD EQUILIBRIUM AND STABILITY

In collaboration with ANL, RPI investigated plasma characteristics which optimize the impact of the bootstrap effect for the ARIES-I design. The bootstrap effect is an inherent plasma mechanism which generates toroidal current. By optimizing the impact of the bootstrap current, it is possible to reduce the size and cost of the external current drive system required for steady state operation. This is a design direction which enhances reactor performance and economics.

In this effort the RPI activity has focused on MHD stability analyses. Using the PEST code (PPPL), RPI performed extensive parametric studies of MHD stability at an aspect ratio of 6, varying elongation, triangularity and safety factor. Both ballooning and kink stability were examined.

It was found that increasing the safety factor while maintaining stability can provide large bootstrap contributions to the plasma current. At the same time, plasma current and beta decreased, requiring an increase in toroidal field strength to maintain constant fusion power. The ANL group showed that the required MHD equilibria could be numerically reproduced by launching properly tailored rf power spectra.

3. PLASMA-EDGE MODELING

In collaboration with UCLA, RPI investigated the performance of a high-recycling, double-null divertor for the ARIES-I design. In this context UCLA employed the EPIC code (E. Vold, 1989) and RPI employed the B2 code (B. Braams, 1987). These codes are 2-D computational tools which are used to predict the performance of the impurity control and particle exhaust system.

Both codes predicted that for a mid-plane separatrix electron density of ~ 10^{20} m^{-3} (corresponding to a recycling coefficient of 0.98), the plasma temperature at the tungsten divertor plate can be kept below ~ 25 eV which should insure acceptable performance with regard to erosion by sputtering. In addition, the code predictions indicated that the peak heat flux would not exceed ~ 4.5 MW/m^2 which would allow the plate to be cooled by helium (the coolant adopted for the blanket and shield systems).

In addition to the results cited above, RPI performed sensitivity studies to examine the robustness of the design to variations in midplane separatrix electron density and recycling coefficient.

4. BLANKET-MATERIALS ISSUES

The structural material adopted for the ARIES-I design is a SiC fiber/matrix composite. This material exhibits very low neutron activation while retaining good strength at elevated temperature. Radiation performance is the key issue associated with the viability of employing SiC composites as structural materials in fusion reactors. Given this situation, RPI in collaboration with ORNL initiated a program to investigate the radiation performance of SiC composites.

The joint ORNL/RPI program involves irradiations employing ion beams, neutrons and photon beams. Mechanical properties will be studied using ion beams and neutron irradiations at ORNL. Electrical properties will be investigated using photon beams at RPI. Preliminary results are expected by the fall of 1990.

DOE F538 (5-86)

OMB Control No. 1910-1400

U. S. DEPARTMENT OF ENERGY
NOTICE OF ENERGY RD&D PROJECT

1. Descriptive TITLE of work (150 characters including spaces)

ARIES TOKAMAK REACTOR STUDY

2. CONTRACT or grant number: DE-FG02-85-ER52118

2A. MASTER contract number (GOCO's): n/a

2B. Responsible PATENT office: ____

3. Performing organization CONTROL number (internal): RPI Proposal No. 18(12R)057(2C)

3A. Budget and Reporting code: AT-15-0301

3B. Funding YEAR for this award:

4. Original contract start date: 12/1/84

4A. Current contract start date: 12/1/90

4B. Current contract close date: 11/30/93

4C. Anticipated project termination date: ____

5. Work STATUS

☐ Proposed ☒ Renewal

☐ New ☐ Terminated

5A. Manpower (FTE): ____

5B. CONGRESSIONAL district: 23

5C. STATE or Country where work is being performed: New York

5D. COUNTRY sponsoring research: ____

6. Name of PERFORMING organization: RENSSELAER POLYTECHNIC INSTITUTE

6A. DEPARTMENT or DIVISION: Nuclear Engineering and Engineering Physics

6B. Street Address: 110 Eighth Street

6C. City, State, Zip Code: Troy, New York 12180-3590

7. Circle only one code for TYPE of Organization Performing R&D:

CU - College, university, or trade school
FF - Federally funded RD&D centers or laboratory operated for an agency of the U. S. Government
IN - Private industry
NP - Foundation or laboratory not operated for profit
ST - Regional, state or local government facility
TA - Trade or professional organization
US - Federal agency
XX - Other
EG - Electric or gas utility

8A. Contractor's PRINCIPAL INVESTIGATOR/s or project manager
Name/s (Last, First, MI): Steiner, Donald and Embrechts, Mark, J.

8B. PHONE/s (in order of PI names with commercial followed by FTS)

Comm. (518) 276-4016 ; FTS ____ ; Comm. (518) 276-4009 ; FTS ____

8C. PI/s address (if different from that of Performing Organization)

____

9. DOE SUPPORTING Organization E Assistant Secretary and office sponsoring work; technical monitor; and administrative monitor).

9A. PROGRAM division or office (full name) Chicago Operations

Program Office Code

9B. TECHNICAL monitor (Last, First, MI) Berk, Sam, E.

9C. Address U.S. Dept. of Energy
ER-533
Germantown, Maryland 20545

9D. Phone Comm. (301)353-4171
FTS

9E. ADMINISTRATIVE monitor (Last, First, MI) Adkins, Keith

10. FUNDING in thousands of dollars (K$). Funds represent budget obligations for operating and capital equipment (FY runs October 1 – September 30).

Funding organization(s)	Current FY 91	Next FY 92
A. DOE	170,833	34,167
B.		
C.		

10D. Does the current FUNDING cover more than one year's work? Yes ___ No X

E. If yes, provide dates (from when to when). ___

11. Descriptive SUMMARY of work. Enter a Project Summary using complete sentences limited to 200 words covering the following: Objective(s), state project objectives quantifying where possible (e.g., "The project objective is to demonstrate 95% recovery of sulphur from raw gas with molten salt recycling at a rate of one gallon per minute."); approach, describe the technical approach used (how the work is to be done); expected product/results, describe the final products or results expected from the project and their importance and relevance.

This research is aimed at developing power reactor embodiments which optimize the potential of fusion energy as an elonomic, safe and environmentally desirable source of energy.

12. PUBLICATIONS available to the publ. List the five most descriptive publications th. .ave resulted from this project in the last year that are available to the public. (Include author, title, where published, year of publication, and any other information you have to complete full bibliographic citation.) Use the back of this form or additional sheets if necessary.

Publications 1., 2. and 3. were presented at the IEEE 13th Symposium on Fusion Engineering, Knoxville, Tennessee, October 2-6, 1989, and will appear in the proceedings of the meeting.

1. "Center Conductor Design for the Compact Spherical TORUS Reactor," L. L. Snead and D. Steiner.

2. "Energy Conversion Options for ARIES - III - A Conceptual D - ^{3}He Tokamak Reactor," J. Santarius, D. Steiner, et al.

3. "The ARIES Tokamak Fusion Reactor Study," The ARIES Team.

4. "Fusion Reactor Economic, Saftey and Environmental Prospects," R. W. Conn, J. P. Holdren, S. Sharafat, D. Steiner, et al., submitted to Nu . Fusion.

13. KEYWORDS (Listed five terms describing the technical aspects of the project. List specific chemicals and CAS number, if applicable.)

Fusion Reactor, Tokomak, Fusion Economics, Fusion Safety, Fusion Engineering

14. RESPONDENT. Name and address of person filling out the Form 538. Give telephone number, including extension (if you have FTS number, please include it) at which person can be reached. Record the date this form was completed or updated. The information in Item 14 will not be published.

Respondent's Name: Donald Steiner Phone No.: (518) 276-4016 Date: 7/23/90

Street: RENSSELAER POLYTECHNIC INSTITUTE

City: Troy State: New York Zip: 12180-3590

15. Additional space for furnishing information in items 1 to 14. (Indicate item numbers to which answers apply.)

Item No.	

NOTICE: Return this form to the office indicated in the reporting requirements for your award agreement covering this project. If you have completed a similar programmatic office project description during the current Fiscal Year, complete only the new data elements on this form and send it and a copy of the description completed earlier to Department of Energy, Office of Scientific Information, P. O. Box 62, Oak Ridge, TN 37831.

END

DATE FILMED

11 / 21 / 90