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(10/20/93)

PROGRAM STATUS 4th QUARTER – FY 1993

ITER & TECHNOLOGY

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General Atomics Project 3469

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OCTOBER 20, 1993

GENERAL ATOMICS

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ITER & TECHNOLOGY 4TH QUARTER FY93

- **Reactor Studies**

- Continued development of the high pressure helium-cooled design for the PULSAR reactor study.

- **RF Technology**

- Fabricated two TE_{22,8} mode generators.

- **Plasma Interactive Materials**

- Operated the DIMES sample changer in a piggyback mode during DIII-D dedicated physics experiments.

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CONTRACT DE-AC03-89ER52153
4TH QUARTER – FY93

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Reactor Studies

PROGRAM STATUS
4TH QUARTER - FY 1993

TASK: REACTOR STUDIES

B/R NO: AT-15-03

FY93 FUNDING: \$300 K

CONTRACT NO: DE-AC03-89ER52153

FY93 PLAN: \$300 K

GA PRINCIPAL INVESTIGATOR: C. P. C. WONG

SAN PROJECT MANAGER: C. BEIGHLEY

OFE PROGRAM MANAGER: S. BERK

PLANNED ACTIVITIES/GOALS	ORIGINAL TARGET	CURRENT TARGET	COMPLETION DATE
1. Complete conceptual design and evaluation of the ARIES-II and IV Tokamak Reactors	2 nd Q FY92		4 th Q FY93*
2. Support the conceptual design of the PULSATOR Tokamak Reactor under the STARLITE program	←	ONGOING	→
3. Participate in the planning of the DEMO stellerator and reactor designs	←	ONGOING	→

REMARKS:

*Completion of the final report.

PROGRAM STATUS

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REACTOR STUDIES

HIGHLIGHTS:

- We found that the high pressure (18 MPa) helium-cooled solid breeder design may be able to breed adequate tritium without the use of Be as the neutron multiplier. Thermal-hydraulics results indicate that the ARIES-IV shield can be used as the thermal storage component, while keeping the outlet coolant temperature constant during the dwell time of about 2 minutes.
-

1. Reactor Design

We continued to develop the high pressure (18 MPa) helium-cooled design for the PULSAR reactor study. Based on 1-D heat transfer calculation, we determined the suitable coolant tube dimensions and blanket widths at different poloidal locations that would satisfy the blanket materials temperature limits. Without the use of Be, we found that an adequate of TBR of 1.13 can potential be obtained with SiC-composite wall thickness of less than 1.8 mm. Since this is a result that goes against the common wisdom of the required use of Be to breed adequate TBR for solid breeder blankets, the PULSAR blanket team decided that more details thermal-hydraulics and multi-dimensional neutronics calculations will be needed to confirm the result. In order to finish the PULSAR study on schedule, the team decided to use the ARIES-IV blanket as the reference design for pulse operation comparison.

We then continued to support the PULSAR design studied on four areas, establishing basic feasibility of the proposed use of the shield as a thermal energy storage, investigating the impact of transient operation to power conversion systems, developing the plant layout of PULSAR, and initiating the gaseous divertor design. Simplified two-dimensional time-dependent thermal hydraulics calculations were performed for the PULSAR shield with a configuration comprising of rows of coolant tube-sheets separated by a packed bed of SiC. The calculations revealed that 2.5 GW thermal discharge could be achieved for dwell periods in excess of two minutes. The conditions under which this is achieved are quite broad: initial shield temperature 900–1100°C, tube diameter 1–2 cm. Pumping power

was found to be reasonable, less than 18 MW. The breadth of parameter space under which sufficient energy discharge is predicted suggests that the shield concept is likely to be feasible for PULSAR.

Limitations of power conversion systems under transient loads and impact on the PULSAR design was evaluated. Key findings were, (1) steam cycle components are incompatible with expected cyclic power loadings, (2) gas turbine components appear to be compatible with cyclic loading, but limited development precludes definitive conclusions, and (3) the small thermal time constant of the blanket will make control of the heat transport system more difficult than that for the Modular High Temperature Gas cooled Reactor (MHTGR).

Work was initiated to identify principles and a logic for developing the PULSAR plant layout. Work was also initiated in the gaseous divertor design for the PULSAR reactor study.

2. Project Coordination

GA continued to coordinate the ARIES and PULSAR designs, including PULSAR project meetings, conference calls and providing support to UCLA to administer the IAEA Workshop on Fusion Reactor Design and Technology.

3. ARIES Final Report

GA's contribution to the ARIES-IV final report was completed.

4. Meetings and Workshops

Wong and Sager attended the International Workshop For Fusion Nuclear Data.

C. Hamilton, L. Stewart and C. Wong attended the IAEA meeting at UCLA. Wong presented a paper on the Helium Cooling of Fusion Reactor.

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RF Technology

PROGRAM STATUS
4TH QUARTER - FY 1993

TASK: RF TECHNOLOGY

B/R NO: AT-15-04-01C

FY93 FUNDING: \$335 K

CONTRACT NO: DE-AC03-89ER52153

FY93 PLAN: \$230 K

GA PRINCIPAL INVESTIGATOR: R.W. CALLIS

SAN PROJECT MANAGER: C. BEIGHLEY

OFE PROGRAM MANAGER: T.V. GEORGE

PLANNED ACTIVITIES/GOALS	ORIGINAL TARGET	CURRENT TARGET	COMPLETION DATE
1. Coordinate U.S./Japan RF Technology Exchange.	1 st Q FY93		1 st Q FY93
2. Organize and host the 2 nd Bi-Annual International ECH Transmission Line Workshop.	1 st Q FY93		2 nd Q FY93
3. Support gyrotron proof-of- principle tests at Varian.	3 rd Q FY92		1 st Q FY93
4. Perform dynamic tuning proof-of-principle test.	3 rd Q FY92		2 nd Q FY93
5. Collaborate on U.S./Japan ICH feed-through testing.	4 th Q FY92		4 th Q FY93

REMARKS:

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RF TECHNOLOGY

HIGHLIGHTS:

- The organization of the 3rd Bi-annual U.S./Japan RF Technology Exchange has been completed. The meeting is scheduled to be held the last week in October and in close proximity to the APS meeting held the following week in St. Louis, Mo.
 - Two TE_{22,6} mode generators were fabricated. One was shipped to the University of Wisconsin in September and one will be shipped to Varian in October. The one shipped to the University of Wisconsin was measured to have a mode purity better than 98%.
 - A report on the testing of the RF vacuum feed-throughs was written.
-

The 3rd Bi-annual International ECH Transmission Line workshop is being organized to be held the week before the 1993 APS meeting. The dates are October 28-29, 1993 and will be held at Inn at Grand Glaize, Osage Beach Mo.

The testing of the feed-throughs at Naka, Japan has been completed and a final report has been written. However even though the feed-throughs show good performance at short pulse, over 70 kV, their hold off voltage drops as the pulse is extended beyond 1 second. The cause of this deterioration is unknown. JAERI is willing to continue the testing at Naka to investigate this phenomenon, and it appears that further testing is justified.

The TE_{22,6} mode generators for testing the internal launchers for the MW gyrotron development program were fabricated this quarter. One unit was assembled, tested and shipped to the University of Wisconsin in September. This unit had over 98% mode purity. The second unit was assembled and will be tested and shipped to Varian in October.

A conceptual design for a 2"X8" distributed gyrotron window was completed this quarter. The long lead materials have been ordered and fabrication of the window frame and vacuum bellows will start in early October.

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ITER & Technology Program

Plasma Interactive Materials

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TASK: PLASMA INTERACTIVE MATERIALS

B/R NO: AT-15-04-01E

FY93 FUNDING: \$350 K

CONTRACT NO: DE-AC03-89ER52153

FY93 PLAN: \$350 K

GA PRINCIPAL INVESTIGATORS: C. P. C. WONG

SAN PROJECT MANAGER: C. BEIGHLEY

OFE PROGRAM MANAGER: M. COHEN

PLANNED ACTIVITIES/GOALS	ORIGINAL TARGET	CURRENT TARGET	COMPLETION DATE
1. Fabricate and install the motorized Divertor Material Exposure System (DIMES) Sample Changer on DIII-D.	2 nd Q FY92		1 st Q FY93*
2. Perform erosion/redeposition experiments on different base and coated materials.	←	ONGOING	→
3. Perform B ₄ C coated material studies in accordance with the U.S./Russia exchange.	3 rd Q FY92		4 th Q FY93*
4. Perform disruption studies	4 th Q FY92		2 nd Q FY94*

REMARKS:

*Experiments and studies must be coordinated with the DIII-D operation schedule.

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4TH QUARTER - FY 1993
PLASMA INTERACTIVE MATERIALS

HIGHLIGHTS:

- The DIMES sample changer is operating reliably. Different samples were exposed to the DIII-D plasma in a piggyback mode during other dedicated physics experiments.
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Sample Changer System

In the first half of July, the DIMES system was thoroughly tested and operated reliably, allowing us to begin performing useful experiments. The capability to exchange samples overnight and be ready for sample insertion into DIII-D the following morning was demonstrated. We have also demonstrated the capability to complete a reasonable exposure experiment as a piggyback to the primary DIII-D experiment.

DIMES Experiments

In July two DIMES samples were exposed to the DIII-D outer divertor strike point plasma. The first sample was a simple ATJ graphite sample used to demonstrate the capability of the sample exchange system. The second sample was a 29-Si implanted sample, used for sensitive measurement of erosion. These samples were shipped to Sandia for examination and analysis. A Si wafer sample was used to look for possible spurious effects from the glow discharge cleaning. This sample was also returned to Sandia for analysis.

The 29-Si implant sample was also found to have a small fleck imbedded into the surface. Analysis of the sample showed some important features. First, impurity deposition was observed. Sharp aluminum, oxygen and niobium peaks were seen in the Rutherford backscattering, indicating these elements were deposited near the surface. This provides confirmation that the projectiles observed in the plasma were mostly alumina pieces being ejected from the bottom of the bias ring. Niobium is also used in the bottom of the bias ring.

Second, significant erosion was measured in some regions of the sample. A peak erosion of 40 nm (± 10 nm) was deduced from the 29-Si Rutherford backscattering peak. In other areas of the sample, no net erosion was observed. This result of erosion/redeposition experiment yielded consistency with the REDEP code developed at ANL. However, validation of that computer model will require exposure of additional DIMES samples under better controlled and documented conditions.

In addition, an ATJ graphite sample was exposed during boronization of DIII-D and the surface is being analyzed.

Disruption Simulation Experiments

A B₄C coated sample of RGT (a recrystallized graphite doped with Ti) provided by TRINITI labs, Moscow, was sent to Sandia, Albuquerque for testing on the high heat flux e-beam facility. The tests went better than expected. The original test plan called for a gradual increase in the power deposition up to a 10 MW/m² level for 5 seconds. The sample and coating survived this power level with no indication of any damage, so the load was increased to 12.5 MW/m² for 5 seconds. Again no damage was observed. The sample was then turned on edge, to test the durability in the direction of poor thermal conductivity (RGT has an anisotropic thermal conductivity). At 5 MW/m² for 5 seconds no damage occurred. This is a very promising result indicating that the coated RGT, with a very high thermal conductivity, may be suitable for applications where present graphites with lower thermal conductivity are unsuitable.

Preparations are being made to perform dedicated erosion and redeposition experiment at DIII-D.

International Collaboration

A Russian DIMES sample with boron carbide coating was exposed to 15 DIII-D discharges during Dr. O. Buzhinskij's scientific exchange visit and then returned to TRINITI for post-exposure surface analysis.

Two ATJ samples were received from SNL-L, dimensions checked and baked out before shipping to Japan for coating with B₄C coating material.

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