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RTNS-II OPERATIONAL SUMMARY

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RTNS-II OPERATIONAL SUMMARY*

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Abstract

The Rotating Target Neutron Source II facility (RTNS-II) operated for over nine years. Its purpose was to provide high intensities of 14 MeV neutrons for materials studies in the fusion energy program. For the period from 1982-1987, the facility was supported by both the U. S. (Department of Energy) and Japan (Ministry of Education, Culture and Science). RTNS-II contains two accelerator-based neutron sources which use the $T(d,n)^4He$ reaction. In this paper, we will summarize the operational history of RTNS-II. Typical operating parameters are given. In addition, a brief description of the experimental program is presented. The current status and future options for the facility are discussed.

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1. INTRODUCTION

The RTNS-II facility began operation in 1979. It was built as a national facility for the U.S. fusion program with the purpose of investigating fusion neutron effects on materials. It was to provide direct data on neutron effects for materials (such as magnets) that will receive a low neutron dose in fusion reactors. It was also to provide information on neutron energy effects in radiation damage by comparison to fission neutron data where neutron and recoil energies are much lower. Finally, nuclear activation and transmutation of fusion materials, including the production of hydrogen and helium could be studied.

Table 1 presents a brief history of RTNS-II. This shows the significant dates from initial funding to cessation of operations. It also indicates when Japanese support and utilization of the neutron sources began. Significant capability was added to the facility at this time in terms of post-irradiation studies. Instrumentation for mechanical testing, x-ray diffractometry and electron microscopy were installed for examination of irradiated samples.

2. THE NEUTRON SOURCES

As noted above, the RTNS-II neutron sources are accelerator-based and use the $T(d,n)^4He$ reaction to generate the high intensities of neutrons. Each accelerator is of the Cockroft Walton type with a nominal maximum voltage of 400 keV. Beam currents ranged from 45 mA at initial operation to 150 mA. Maximum neutron production approached 4×10^{13} n/s. The rotating target system also evolved during the operational period of RTNS-II. Initial operation used an internally-cooled, diffusion bonded, 23 cm diameter target substrate. The Cu-alloy substrate was coated with a 10μ TiT_2 layer of ~300 cm^2. To increase total neutron yield, a 50 cm electro-formed substrate was developed which had a TiT_2 layer of ~1500 cm^2. Detailed descriptions of the accelerators and target systems have been given elsewhere (1,2,3).

Table 2 gives characteristic operational parameters for the neutron sources. These refer to the first neutron source (designated left machine) but are typical for both.

During the course of operations, data were collected for various items ranging from neutron production to machine outages. These are summarized in Table 3 and cover virtually the entire period during which irradiations were conducted. The scheduled outage shown includes periods of time when a neutron source was not scheduled to operate.

3. EXPERIMENTAL PROGRAM

In this section, we wish to briefly describe the content of the experimental program carried out at RTNS-II. Irradiations generally were in one of two categories. These were "primary" and "add-on." The first involved using the primary irradiation volume and higher fluences ($\sim 10^{18}$ n/cm^2), while in the latter, the sample was located farther away ($\geq$10 cm) and the fluence requirement was less ($\sim 10^{15}$ n/cm^2). Several "add-on" experiments could be done concurrently with a "primary" irradiation. Specific details of the experimental program are given elsewhere (4). Sample irradiation conditions were widely varied. For example, sample temperatures ranged from 4°K to 873°K. Samples were passive or had "on-line" control. Measurements were done "on-line" or post-irradiation. For completeness, a broad outline of the experimental program is given in Table 4. This table includes both categories of irradiations.

The number of irradiations performed at RTNS-II numbered nearly 500. These involved people from several countries and nearly 40 different laboratories/universities. The number of samples irradiated numbered in the tens of thousands. For example, the high temperature experiments on metals and alloys involved a few thousand different samples.

4. CURRENT STATUS

As previously noted, the irradiation program ended in June 1987. After an initial period to allow induced activity to decay, the facility was put in a state of "warm" shutdown. By this, we mean the facility could have been restarted in a relatively short period of time (~2 weeks). Initial cleanup and disposal of unneeded components was also begun. As time progressed, the facility was moved to a "cold" shutdown in which all systems were secured. Vacuum systems were shutdown and sealed to prevent residual tritium from escaping. Also, a more extensive cleanup of lightly-contaminated areas was begun. This effort is continuing at the present time (September 1988). The facility at this time remains essentially intact, but totally shutdown.

5. FUTURE USES

The experience gained during operation of the RTNS-II has been very valuable for operation of high-current DC neutron generators. In fact, an upgrade of a RTNS-II type machine would seem to be possible with a very high chance of success. Upgrades of RTNS-II have very briefly been discussed before (5). In addition, the experience gained at the Multi-User Tandem Laboratory (6) with regard to computer control systems (7) would indicate that operations could very well be simplified and more automated. From the experience gained, a factor of three upgrade in neutron yield would appear to be a very good possibility. In fact, a large percentage of the components of a present neutron source could be used in such an upgrade. This is illustrated in Table 5 where the separate sub-systems of a neutron source are shown and the general changes needed to implement the upgrade are given. As can be seen, the required number of modifications are not large, and, in most cases, the needed equipment is already available.

6. SUMMARY

The RTNS-II facility has successfully completed over nine years of irradiations in support of the fusion energy program. A wide variety of experiments were done providing a large amount of information on the interaction of 14 MeV neutrons with materials. While the facility is not presently in operation, it remains essentially intact. Should the need arise, the facility could be put back into operation and in fact could very likely be upgraded relatively easily.

The successful irradiation program at RTNS-II was the result of valuable contributions made by a great many people. On behalf of the project, their work is gratefully acknowledged.

Table 1

HISTORY OF RTNS-II

Year	Event
March 1976	Funding granted
March 1978	Building completed
September 1978	First neutron source operational
November 1978	First neutrons produced
March 1979	Irradiations begin
March 1982	Japan joins project
June 1983	Second neutron source activated
June 1987	Irradiations cease

Table 2

OPERATIONAL CHARACTERISTICS

	Initial	Final
Arc current	35 A	50 A
Extraction voltage	25 kV	35 kV
Beam current (max)	45 mA	150 mA
Total beam energy	360 kV	370 kV
TiT_2 target size	23 cm	50 cm
TiT_2 target content	~1200 Ci[(a)]	~5500 Ci[(a)]
Target rotation speed	5000 Hz	3500 Hz
Neutron source strength	1×10^{13} n/s	3.7×10^{13} n/s

(a) TiT_2 target dependent

Table 3

OPERATIONAL DATA 6/79 THROUGH 5/87

	Left	Right[a]
Total hours available	38,220 hrs	17,450 hrs
Total scheduled outage	12,035	7,545
Total unscheduled outage	7,425	3,300
1) target system	3,280	740
2) ion source	675	320
3) HV terminal electronics	1,110	945
4) vacuum system[b]	1,220	620
5) other	1,140	680
Total coulombs of beam[c]	$5.1x10^6$	$2.2x10^6$C
Total neutrons produced	$5.6x10^{20}$	$2.6x10^{20}$

(a) Right Machine activated 6/83
(b) does not include target vacuum system
(c) 1C = $6.3x10^{18}$ deuterons

Table 4

GENERAL OUTLINE OF EXPERIMENTAL PROGRAM

Category	Property Studied
Metals and alloys	Mechanical properties Microstructure - TEM Electrical resistivity Helium production
Superconducters	Critical current Critical temperature Critical field
Insulators	Electrical properties Mechanical properties
Cross sections/activation	14 MeV neutron cross sections Neutron source characterization
Tritium production	Post-irradiation and in-situ measurement of tritium production in blanket materials
Optical components	Changes in transmission or index of refraction
Detector/electronic components	Detector calibration and development effects of neutrons on electro-optical components

Table 5

SYSTEM CHANGES FOR A RTNS-II UPGRADE

Subsystem	Change
High voltage	
1. 400 kV supply	Combine present two
2. HV terminal	No change
3. Isolated power	May require some small additional capability
Ion source system	
1. Ion source	Additional output needed
2. Vacuum system	No change
3. Controls	See below
Acceleration column	Upgrade with new design column on hand
Beam transport system	
1. Vacuum system	No change
2. Controls	See below
3. Optics	No change
Diagnostics	
1. Beam spot	Improved size and position diagnostics
2. Neutron monitoring	No essential change
3. RGA capability	Implement
Rotating target system	
1. Rotating seal	No change
2. Target substrate	No change
3. TiT_2 layer	No change
4. Cooling	May need upgrade
5. Controls	See below
Radiological systems	
1. Shielding	No change
2. Tritium scrubber	No change
3. Remote handling system	Implement
Control systems	All control systems would be upgraded using system and techniques described in Ref. 7

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