STATUS REPORT OF INDONESIAN RESEARCH REACTORS

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ABSTRACT

A general description of the three Indonesia research reactors, their irradiation facilities and future prospect are given.

The 250 kW Triga Mark II in Bandung has been in operation since 1965 and in 1972 its designed power was increased to 1000 kW. The core grid from the previous 250 kW Triga Mark II was then used by Batan for designing and constructing the Kartini reactor in Yogyakarta. This reactor commenced its operation in 1979. Both Triga reactors have served a wide spectrum of utilization such as for manpower training in nuclear engineering, radiochemistry, isotope production, and beam research in solid state physics.

The Triga reactor management in Bandung has a strong cooperation with the Bandung Institute of Technology and the one in Yogyakarta with the Gadjah Mada University which has a Nuclear Engineering Department at its Faculty of Engineering.

In 1976 there emerged an idea to have a high flux reactor appropriate for Indonesia's intention to prepare an infrastructure for both nuclear energy and non-energy industry era. Such an idea was then realized with the achievement of the first criticality of the RSG-GAS reactor at Serpong area. It is now expected that by early 1992 the reactor will reach its full 30 MW power level and by end of 1992 the irradiation facilities be utilizable fully for future scientific and enqineerinq work.

As a part of the national LEU fuel development program a study has been underway since early 1989 to convert the RSG-GAS reactor core from using oxide fuel to usinq hiqher loadinq silicide fuel.

I. INTRODUCTION

National Atomic Energy Agency of Indonesia or Badan Tenaga Atom Nasional (BATAN) owns and operates three research reactors, namely two Triga type low flux reactors and one high flux multipurpose reactor.

The first reactor, the Triga Mark II reactor located at Bandung West Java, is a thermal, light water moderated and cooled, open pool type research reactor. It became critical in 1965 and operated at a power of 250 KW. The power level was upgraded, following a total renewal of the core grid, cooling and instrumentation system to 1000 KW in 1972. The reactor was initially introduced together with the Bandung Institute of Technology as the first tool to gain know how in nuclear technology.

The Kartini Research Reactor, the second reactor, which is located at Yogyakarta, Central Java, is a similar Triga type reactor, designed for an operation up to 200 KW thermal power. Using Triga reactor as a reference and used components from Bandung reactor, Batan staff designed and constructed the Kartini reactor which achieved its criticality in 1979. The purpose of the reactor has been implemented by Batan together with Gajah Mada University which has a faculty of Nuclear Engineering.

Since 1976 the idea to have high flux reactor has been foreseen appropriate to Indonesian intention to prepare infrastructure for nuclear industry for both energy and non-energy related activities.

Using experience gained during the construction and operation of the two previous reactors and their supporting facilities, Batan has developed specifications and objectives of the Centre for Nuclear Industry Development at Puspiptek area.

The facilities are of Multipurpose Research Reactor (RSG-GAS) and its affiliated facilities such as, the Fuel Element Production Installation (FEPI) for the production of MTR type fuel elements, the Experimental Fuel Element Installation (EFEI) and the Radiometalurgy Installation (RMI) for gaining know-how on power reactor fuel. Other facilities include the Radioisotope Installation (RII) for processing various radioisotopes, the Engineering and Safety Installation (ESI) and the Nuclear Mechano-Electronic Installation (NMEI) for obtaining know-how in nuclear engineering and manufacturing capability of special nuclear components and finally the Radioactive Waste Installation (RWI) for gaining capability to manage and handle radioactive wastes in Indonesia.

The idea came to realization with the first criticality of RSG-GAs in July 1987 and since then the reactor has been in Commissioning stages to reach full power of 30 MW by early 1992. By the end of 1992 irradiation facilities at RSG-GAS will have been installed and commissioned.

The role of Triga type reactor is mainly for training, research and isotope production. This reactor is classified as a low flux research reactor which will be used to complement the RSG-GAS which has neutron fluxes exceeding 10^{14} n/cm^{2}s.

Small research reactors in Indonesia have demonstrated their abilities as the focal point for broad range of nuclear technology transfer and as the training ground for developing techniques prior to construction of larger reactors.

Research reactors provide powerful tools for researches in nuclear physics, materials science, fuel technology, analytical chemistry, nuclear safety, control instrumentation and radioisotope production for agriculture, industry, and medicine and as well provides basic infrastructure for the personnel training for future nuclear power stations.

II. REACTORS DESCRIPTION

To discuss the status of research reactors in Indonesia, Table 1 gives the basic features of BATAN Research Reactors.

The Triga II Reactor operating at normal power of 1000 KW is cooled and moderated with demineralized light water circulated in a closed circuit. The cylindrical tank which houses the reactor core is of alumunium of 6 m in height and 2 m in diameter.

The generated heat is dissipated through a heat exchanger to the secondary coolant which in turn discharges the heat through the coolinq tower.

The operating pattern of Triga reactor depends on the need, for example, during radioisotope production the reactor may be operated for 7 day-continuous-power operation.

The irradiation devices inside the reactor tank are installed in a core position of either in the fuel region or in the reflector region. The rotating radioisotope production facility called Lazy Susan provides irradiation space for 80 irradiation capsules. One pneumatic tube permanently installed provides possibilities for short-term irradiation of samples with a very short transit time, necessary for studying very short-lived activation products.

The Kartini Reactor has been designed similar to the Triga Mark II reactor. A unique advantage of that reactor is that the reactor is coupled to the natural uranium light water subcritical assembly through one of its beamports.

The basic design of both the Triga Mark II and Kartini Reactors is highly inherently safe using UZrH fuel, which means that any mechanical or human error would not give serious risk. This makes it suitable for training purposes.

Table I. Basic Features of Indonesian Research Reactors

	Triga Mark II	Kartini	RSG-GAS
Reactor Type	Tank	Tank	Tank
Date of Criticality	20 Feb. 65	25 Jan. 79	29 July 87
Reactor Power	1000 KW	200 KW	30 MW
Fuel	UZrH, 19.7% enriched	UZrH, 19.7S enriched	U3Os-Al, 19.75% enriched
Fuel Element Type	Rod	Rod	Plate
Fuel Cladding	St. steel	Al	AlMg2
Core Size	H (55 cm) D (53 16 cm)	H (55 cm) D (45.7 cm)	H (73.8 cm) L (80.6 cm) W (76.1 cm)
Max. thermal neutron flux (n/cm2sec)	10^{12}	10^{11}	3.5×10^{14}
Moderator	light water	light water	light water
Coolant	light water nat. circ.	light water nat. circ	light water forced circ.
Control Rod	B4C	B4C	Ag-In-Cd
Utilization	-Training -R&D in nuclear-technology -Radioisotope production/NAA -Beam tube experiment	-Training -Reactor physics studies -NAA	-Materials testing -Radioisotope production -Beam tube experiment -fuel testing -traininq

RSG-GAS is a multipurpose reactor with a normal operating power of 30 MW termal. The reactor is cooled and moderated with demineralized light water circulating in a closed circuit.

The rectangular core is arranged at 13.75 m deep tank pool. It consists of a 10x10 array of grid containing 40 fuel elements, 8 control fuel elements, one Central Irradiation Position, 4 Irradiation Positions, 37 beryllium reflector elements and one beryllium block in L-geometry as reflector at two sides of the core. The beryllium block houses 6 beam tubes in it, penetrating the reactor tank and biological shielding at the experimental hall level. The fuel elements contains

U_3O_8-Al with 19.75% enrichment in 21 plates for standard element and 15 plates for control element

The generated heat is dissipated in two heat exchangers to the secondary coolant which in turn discharges it through the cooling tower.

The operating pattern of RSG-GAS follows a 27-day-operating period in one cycle.

III. RESEARCH AND UTILIZATION

In appropriate to nuclear application in energy and non-energy fields in Indonesia, it seems no need to emphasize the tremendously important role of the human factor.

The two Triga type reactors have subsequently survived for 26 years and 12 years of operation time. During this period, technicians, engineers and scientists have learned many activities through operation, maintenance and utilization of the reactor facilities.

Human resource development based on interdisciplinary applications of low flux research reactors is set forth in table 2.

Table 2. Interdisciplinary applications of low flux Research Reactors in Indonesia

Reactor Physics and Core Thermohydraulic
Operator and Student Training
Nuclear Instrumentation Health Physics and Radiation Protection
Radioactive Waste Disposal
Activation Analysis
Hot Atom Chemistry
Neutron Diffraction
Biology
Radioisotope Production for Medical, and Industrial
Nuclear Engineering (Process and Water Chemistry)
Neutron Radiography

A basic education in nuclear engineering for students of the Department of Nuclear Engineering, Gadjah Mada University and Nuclear Specialist School of Batan was established and it is allowed mainly for the study of handling radiation sources, the application of radiation measuring technique and shielding properties of different materials. Furthermore, experiments are supplemented with the following:

- criticality experiments,
- reactivity changes due to variations of the core configurations or insertion of different materials

- measurements of neutron flux
- control rod characteristics
- radiation field In the vicinity of the reactor
- reactor operation
- power calibration.

Similar activities or experiments for reactor operators and supervisors allow for particular difference in depth of theoritical knowledge and number of practical training.

Other reactor utilization and experiments using low flux research reactor in neutron diffraction, chemistry, biology, reactor physics and neutron radiography are already described elsewheres (1, 2, 3, 4)

Owing to limited availability of neutron flux BATAN aid research and application in some areas which have been performed only to a limited extent, such as, beam tube experiments, radioisotope production, fuel and material testing, neutron radiography, silicon doping and neutron activation analysis.

To accomodate the increasing demands in areas mentioned above, a multipurpose reactor with a high neutron flux and its incorporated irradiation facilities were constructed (5)

In the construction of such a high flux reactor, several considerations have been performed owing to the evolution in two specific experimental reactor areas1) technology state of art and 2) utilization programs which have to be adapted (6), such as

- needs for higher neutron flux available for experiments which generally obtained by higher reactor powers,
- development in reactor and its irradiation technology which should confirm with the latest safety ctiteria,
- development in experimental irradiation program,
- imposed utilization of Low Enriched Uranium (LEU).

Experimental facilities at RSG-GAS will be fully installed in 1992. These irradiation facilities could be specified in three different areas of application. i.e Fundamental Research, Applied Research and Production by Neutron Irradiation as shown in Table 3.

The status of RSG-GAS core configuration now reaching 6th core and being due to the installation of inpile loop system reactor will resume operation in January 1992. Starting on the third core, reactor has been used to perform irradiation services such as:

- Irridium-192 (two batches of production tests for consumers)
- Fission product molybdenum (bi-weekly)
- Silicon doping (testing, commissioning and characterization, 2 batches for Japanese Company)
- Hot start up of the NDT and TAS
- Irradiation of the fuel assemblies (domestic manufactured fuels, 2 silicide and 2 oxide fuels)

- Experiment using powder diffractometer (in cooperation with JAERI two paper have been published).

Upon completion of the low power and qualification test, it is expected that by February 1992 the reactor will reach its full power operation of 30 MW thermal.

Table 3. Utilization of Facilities at RSG-GAS

Type of activities	Facility	Number	Note
Fundamental Researches	1) Triple axis spectrometer (TAS) at beam tube S-4	1	Materials science and solid state physics
	2) SANS and HRSANS at S-5	1	
	3) Powder Diffractometer / High Resolution powder diffractometer	1	
	4) Four Circle Diffractometer and Texture Diffractometer	1	
Applied Researches	1) Dynamic Neutron Radiography (at beam tube S-2)	1	NDT, Inspection of com position
	2) Wet Neutron Radiography (inpool)	1	Fuels/Materials
	3) Power Rampt Test Facility		Fuels
	4) PWR/PHWR inpile loop (CIP)		Fuel
	5) Capsules (pins and Cyrano)	2	Fuels/Materials
	6) Pneumatic Rabbit System	1	NAA
Production by Neutron Irradiation	1) Be Reflector irradiation hole	4	Isotope production
	2) Neutron Transmutation Doping	1	Si doping
	3) Irradiation Capsule at IP	2	Isotope production
	4) Iodine loop	1	Isotope production
	5) Hydraulic Rabbit System	4	Isotope production, NAA

IV. FUTURE PROGRAMS

Appropriate to evolution in experimental reactor technology and its utilization program there are still two main criteria which have to be adapted for the reactors existing in Indonesia. Firstly, the existing reactor and its irradiation facilities should conform with the latest safely criteria and secondly, developing and optimising utilization of existing reactor facilities should relate to the latest development.

With the existing facilities in which some still need improvement, the most important resource is the people who will design, implement, and evaluate experiments being performed and last but not least the people who will operate and maintain the facility. All the people involved should have certain qualifications, such as, trained and experienced engineers, scientists and technicians.

Due to these facts, the reactor utilization in Indonesia will be divided into 1) Fundamental Research 2) Applied Research 3) Production by Neutron Irradiation and 4) Training and Familiarization.

The reactor utilization in the future will be expected to be as shown in Table 4 below.

Table 4. The future Utilizatiorl of Research Reactors (given in percentage of activities)

	Fundamental Research	Applied Research	Production by Neutron	Training
Triga Mark II	20	10	40	30
Kartini	30	5	5	60
RSG-GAS				
(as designed)	30	30	30	10
(1992-94)	20	10	40	30

Ideally, the status of RSG-GAS as a multipurpose reactor has to accomodate 3 main activities in the early period (92-94) such as the production by neutron irradiation readily available, training familiarization to more sophisticated equipment and needs for basic know how for fundamental and applied research activities. The immediate activities will be for reorientation and relocation of human resources in terms of optimizing utilization of the reactor. Furthermore, for :

1. Kartini Reactor
   - to equip reactor with additional facilities for training and fundamental researches.

2. Triga Mark II
   - to renovate old part of reactor system
   - to maintain reactor as a complimentary to RSG-GAS for radioisotope production

3. RSG-GAS
   - to maintain availability of the reactor for user and experimenter in the safe manner (5 cycles/year)
   - to have the basic data of all irradiation facilities
   - to familiarize with behaviour of reactor and its irradiation facilities
   - to see the possibility of using U3Si2 as a reactor fuel.

Possible utilization of research reactors in reactor operation and maintenance, irradiation services/experiments, post irradiation experiments and technical developments under International Research programs will be highly appreciated.

The specific program directly related to RERTR since early 1989 study has been going on to look for a possibility to convert LEU Oxide to LEU Silicide fuel at RSG-GAS, as a part of fuel technology development for a research reactor

Development studies should include three main field of activities 1) Fuel Fabrication, 2) Fuel Qualification and 3) Conversion studies. Fuel Fabrication activities have been implemented with full support by IAEA and ANL. For Fuel Qualification, 2 Oxide and 2 Silicide fuels were under irradiation at RSG-GAS core

These full size irradiation has reached 8 % and 16 % burn up and number of visual inspection have shown excellent results.

The objectives of conversion study are to revise existing Safety Analysis Report to be reviewed by Regulatory Body which covered nuclear, thermal hydraulic and safety studies. The studies will also be used to develop fuel specification for manufacturers and incore fuel management including core transition reactor operators.

It i6 expected that by using higher density and higher burn up Silicide fuel, the penalty contained at existing RSG-GAS LEU Oxide fuel up to certain extends could be compensated.

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