2. Status Report of Indonesian Research Reactor

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ABSTRACT

A general description of three Indonesian research reactor, its irradiation facilities and its future prospect are described.

Since 1965 Triga Mark II 250 KW Bandung, has been in operation and in 1972 the design powers were increased to 1000 KW. Using core grid form Triga 250 KW BATAN has designed and constructed Kartini Reactor in Yogyakarta which started its operation in 1979. Both of this Triga type reactors have served a wide spectrum of utilization such as training manpower in nuclear engineering, radiochemistry, isotope production and beam research in solid state physics.

Each of this reactor have strong cooperation with Bandung Institute of Technology at Bandung and Gajah Mada University at Yogyakarta 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.

The idea come to realization with the first criticality of RSG-GAS (Multipurpose Reactor G.A. Siwabessy) in July 1987 at PUSPIPTEK Serpong area. It is expected that by early 1992 the reactor will reached its full power of 30 MW and by end 1992 its expected that iradiation facilities will be utilized in the future for nuclear scientific and engineering work.

I. INTRODUCTION

National Atomic Energy Board of Indonesia or Badan Tenaga Atom Nasional (BATAN) owned and operated three research reactors which consist of two Triga type low flux reactors and one high flux multipurpose reactor.

The first reactor, 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 total renewal of the core gird, cooling and instrumentation system, to 1000 KW in 1972. The reactor is initially introduced together with Bandung Institute of Technology as the first tool to gain know how in nuclear technology.

Kartini Research Reactor as a second reactor located at Yogyakarta, Middle Java, is a similar Triga type designed for operation up to 200 KW thermal power. Using Triga reactor as a reference and used component from Bandung, Batan staff had designed, and constructed Kartini reactor which obtained its criticality in 1979. The reactor utilization 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.

Having experience gained during operation and construction of previous two reactors and its supporting facilities Batan has developed specification and objective of Centre for Nuclear Industry Development at Puspiptek area which consists of Multipurpose Research Reactor (RSG-GAS) and its affiliated facilities such as Fuel Element Production Installation (FEPI) to produce MTR type fuel element, Experimental Fuel Element Installation (EFEI) and Radio Metalurgy Installation (RMI) to gain know how on nuclear fuel for power reactor, Radio Isotope Installation (RII) to process various radioisotopes, Engineering Safety Installation (ESI) and Nuclear Mechano Electric Installation (NMEI) to obtain know how in nuclear engineering and manufacturing capability of special nuclear component and Radioactive Waste Installation (RWI) to have capability to manage and handle radioactive waste in Indonesia.

The idea come to realization with the first criticality of RSG-GAS in July 1987 and since then reactor has been in commissioning stage to reach full power of 30 MW by early 1992 and by end of 1992 it is expected that irradiation facilities at RSG-GAS have been installed and commissioned.

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

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

Research reactors provide powerfull tool for research in nuclear physics, material science, fuel technology; analytical chemistry, nuclear safety and control instrumentation, radioisotope production for agriculture, industry medicine beside providing also the basic infrastructure for training personal for future nuclear power stations.

II. REACTORS DESCRIPTION

For discussing the status of research reactors in Indonesia, table I gives the basic features of BATAN Research Reactors.

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 Material	UZrH, 19.7% enrichment	UZrH, 19.7% enrichment	U3O8Al 19.75 % enriched
- Fuel Element	Rod	Rod	Plate
- Fuel Cladding	St. steel	Al	AlMg
- 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)
- Maximum thermal neutron flux (n/cm^2sec)	$10^{10}-10^{12}$	$10^{10}-10^{11}$	3.5×10^{14}
- Moderator	light water	light water	light water
- Coolant	light water (Natural circ.)	light water (Nat. Circ)	light water (Forced Cooling)
- Control Rod	B4C	B4C	AgIndCd
- Utilization	- Training - R&D in nuc lear tech. - Radio Iso tope Pro- duction/NAA - Beam Tube Experiment	- Training - Reactor Physics Studies - NAA	- Material testing - Isotope production - Beam tube Experiment - Fuel testing - Training

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

The generated heat is dissipated in one heat exchanger to secondary coolant which than discharged the heat through cooling tower.

The operating pattern of Triga reactor depend on the need, for example to produce reactor radioisotope may be operated for 7 days continous power operation.

Inside the reactor tank the irradiation devices installed in a core position of the fuel region or of the reflector region. Rotating radioisotope production facility called Lazy Susan provide irradiation space for 80 irradiation capsule. One pneumatic tube permanently installed provides possibility for short term irradiation of samples with a very short transit time, which is necessary for studying very short lived activation products.

Kartini Reactor has similar design to Triga Mark II reactor with unique advantage is that the reactor is coupled to the natural uranium light water subcritical assembly through one of its beamport.

The basic design of both Triga Mark II and Kartini Reactor is highly inherent safe using UZrH fuel which means that mechanical or human error would not give serious risk make it suitable for training purposes.

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

The rectangular core arranged at 13.75 m deep tank pool. A 10x10 array of grid containing 40 fuel assemblies, 8 control fuel elements, one Central Irradiation Position, 4 · Irradiation Positions, 37 beryllium reflector elements and beryllium block in L size as reflector for two sides of the core. Inside the beryllium block housed 6 beam tubes penetrating reactor tank and biological shielding at experimental hall level. The U3O8Al fuel element with 19.75 enrichment consist of 21 plate for standard element and 15 plate for control element.

The generated heat is dissipated in two heat exchangers to the secondary coolant which is taken and discharged through cooling tower.

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

III. RESEARCH AND UTILIZATION

In appropriate to nuclear application in energy and non energy field in Indonesia there seems no need to emphasize the tremendously important role of the human factor.

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

Human resource development based on interdisciplinary application of low flux research reactor are set forth in table II.

Table II. Interdisciplinary applications of low flux Reaseach Reactors in Indonesia

Reactor Physics and Core Thermohydraulic
Operator and Student Training
Nuclear Instrumentation
Health Physics and Radiation Portection
Radioactive waste disposal
Activation Analysis
Hot Atom Chemistry
Neutron diffraction
Biology
Isotope Production for Medical, and Industrial
Nuclear Engineering (Process and water chemistry)
Neutron Radiography

A basic education in nuclear engineering for student of Dept. of Nuclear Engineering, University of Gajah Mada and Nuclear Specialist School of Batan was established which allowed mainly 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 configuration or insertion of different material
- measurement of neutron flux
- control rod characteristics
- radiation field in the vicinity of the reactor
- reactor operation
- power calibration

Similar activities or experiment for reactor operator and supervisor allow in 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 has been described elsewhere (1,2,3,4).

Owing to limited availability of neutron flux, research and application in some area has been performed only to a limited extent such as beam tube experiment, radioisotope production, fuel and material testing, neutron radiography, silicon doping and neutron activation analysis.

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

In the construction of such high flux reactor several consideration has been performed owing to the evolution in two specific experimental reactor area 1) technology state of art and 2) utilization program which have to be adapted (6) such as :

- need for higher neutron flux available for experiment which generally obtained by higher reactor power,
- development in reactor and its irradiation technology which should confirm with the latest safety criteria,
- 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 area of application i.e Fundamental Research, Applied Research and Production by Neutron Irradiation as in Table III.

Table III. Utilization Facilities at RSG-GAS

Type of activities	Facility	No	Note
Fundamental Research	1) Triple axis spectrometer (TAS) at beam tube S-4	1	Material 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 Research	1) Dynamic Neutron Radiography (at beam tube S-2)	1	NDT, Inspection of composition
	2) Wet Neutron Radiography (inpool)	1	Fuel/Material
	3) Power Rampt Test Facility		Fuel
	4) PWR/PHWR inpile loop (CIP)		Fuel
	5) Capsules (pin+ Cyrano)	2	Fuel/Material
	6) Pneumatic Rabbit System	1	NAA

Activities	Facility	No	Note
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 and NAA

Status of RSG-GAS core configuration now reached 6th core and due to the installation of inpile loop system reactor will resume operation January 1992. Starting on third core, reactor had been used to performed irradiation services such as :

- Irridium-192 (two batches production test for consumer)
- 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).

After low power and qualification test it is expected that by February 92 reactor will reached full power operation of 30 MW thermal.

IV. FUTURE PROGRAMS

Appropriate to evolution in experimental reactor technology and its utilization program there are still two main criteria has to be adapted for the reactors existing in Indonesia. Firstly to make sure that the existing reactor and its irradiation facilities should confirm with the latest safety criteria and secondly developing and optimising utilization of existing reactor facilities in accordance to the latest development.

With existing facilities in which some still need improvement the most important resource is the people who will design, implement, and evaluate experimental being performed and last but not least the people to operate and maintain the facility. All the people involve should have certain qualification which means trained and experienced engineers, scientists and technician.

Due to this fact 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 based on number of activities (%) will be expected as :

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

In case of RSG-GAS because of its status as a multipurpose reactor idealy has to accomodate 3 main activities in a similar manner even though in the early period (92-94) the main activities will be production by neutron irradiation which is readily available and training/familiarization to more sophisticated equipment and need for basic know how for Fundamental and Applied Reasearch activities. Immediate activities will be reorientation and relocation of human resource in order to have optimum utilization of the reactor and furthermore for :

1. Kartini Reactor
   - to equipped reactor with additional facilities for training and fundamental research.

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 experiment and technical development under an International Research program will be highly appreciated.

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