JP0050176

1.34 CURRENT STATUS, RESEARCH PROGRESS AND FUTURE PLAN OF KARTINI RESEARCH REACTOR

Y. Sardjono, Syarip and T.W. Tjiptono, *

ABSTRACT

CURRENT STATUS, RESEARCH PROGRESS AND FUTURE PLAN OF KARTINI RESEARCH REACTOR. The current status, research progress and future plan of the Kartini Research Reactor (KRR) is presented. The measurements of axial burn-up distributions for each fuel element by gamma scanning techniques, core axial power distribution display, fuel management for safeguards purpose as well as some research progress activities i.e.; utilization of beamport for: neutron radiography, application neutron activation analysis and history record of KRR power operations is also presented. The KRR is 100 kW pool water reactor type which uses natural circulation and provided by: five beamports in which one of them already coupled with natural uranium subcritical assembly , two thermalizing columns in which one of them is prepared for developing Boron Neutron Capture Therapy (BNCT), two rabbit systems utilized for special analysis uranium ore by delayed neutron counting techniques, one center timble and 40 irradiation rack (lazy susan) for neutron activation analysis. The KRR was constructed as a second research reactor in Indonesia with special purpose for training and education, high safety margin with involve in high negative temperature coefficient which achieved its first criticality on January 25, 1979. The maximum power level on first criticality is 50 kW and since August 1981 up to now is operating 100 kW. Base on the KRR design limit, it is planned to increase the power level up to 250 kW in the future plan. The preliminary activities such as Non Destructive Testing (NDT) for some reactor components especially water tank and thermal column should be done before decided to increase power level.

I. HISTORICAL PERSPECTIVES

In the early 1970s, National Atomic Energy Agency (BATAN) initiated studies of a transferring Bandung 250 kW TRIGA Mark II to Yogyakarta Nuclear Research Center, central of Java. These studies stimulated extensive discussions within BATAN's superior and BATAN's researcher community and immediately attracted favorable attention from academic institutions especially Gadjahmada University and home made industry as well as central hospital in Yogyakarta and others. As a result of this widespread interest, several cooperative study programs were initiated. Table 1 summarizes the various programs that been undertaken since the transferring Bandung 250 kW TRIGA Mark II to Yogyakarta Nuclear Research Center.

Table 1. Summary of completed KRR-Related studies up to commissioning[3]

No	Program	Principal Activities	Client	Participants	Period of Performance
1	Initial BATAN Studies	Construction the first Indonesia Research Reactor, Bandung 250 kW TRIGA Mark II, west of Java	GA. Technologies Inc. San Diego, California USA.	GA.Tech.Inc. USA.& BATAN.	1961-1965
2	Commissioning 250 kW TRIGA Mark. II	Commissioning TRIGA Mark II at a maximum power 250 kW.	GA. Technologies Inc. San Diego, California USA.	GA. Tech. Inc. USA. and BATAN	February 20, 1965
3	Upgrading of Bandung 250 kW TRIGA. Mark. II	Replacement fuel elements type(from 102 type to 106 type) and control rods.	BATAN	BATAN	December, 1971
4	Team work for the Kartini Research Reactor (KRR)	Planning and implementing the KRR. construction, realizing that the erection of the second reactor was to use domestic capabilities, and using core, fuels and components that they already had.	BATAN	BATAN & Indonesia contractors	1974-1975
5	Civil Engineering construction & mechanical installation of KRR	Installation and construction for biological shielding, instrumentation, core, heat exchanger, primary & secondary systems, auxiliary systems	BATAN	BATAN & domestic engineer	started on 1975
6	First criticality of KRR.	The KRR had reached its criticality and was inaugurated on March 1979 by President of Indonesia. The beginning power level was only 50 kW and since august 1981 the KRR was already operated 100 kW up to now.	BATAN	BATAN domestic engineer	January 25, 1979

II. PLANT FEATURES

The KRR is extremely simple in physical construction. It has a graphite-reflected core capable of operating up to 250 kW steady-state. The reactor core is installed at the bottom of an aluminum tank. Surrounding concrete and demineralized water provide the required radial and vertical shielding. Core cooling is achieved through natural convection, eliminating the need for an expensive and restrictive forced cooling system. The KRR are normally equipped with several irradiation facilities such as:

- Central thimble for high-flux irradiation
- Pneumatic Rabbit with in-core terminus
- Rotary specimen rack (lazy susan) for uniform irradiation of up to 80 sample containers.
- Beam Ports
- Thermal Column

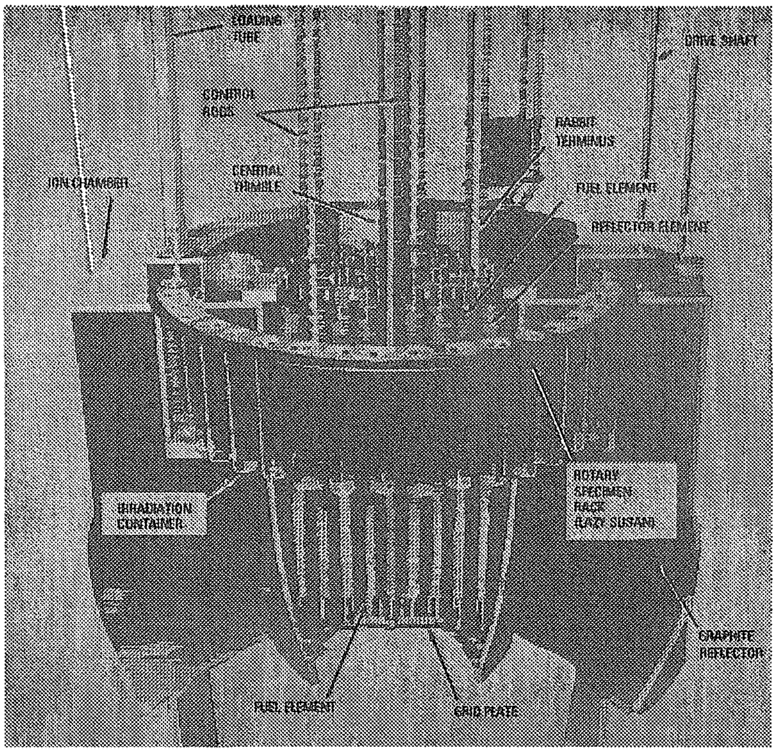

Figure 1: Plant features of core facility of the KRR[4]

II.A. Experiments With Spent Fuel Elements

II.A.1. Gamma Scanning of Spent Fuel Elements

The gamma scanning of spent fuel elements was performed, but no comparison was made with calculated or other experimental information. Following figure 1. for the fifteen spent fuel elements, gamma scanning was performed after reloaded from reactor core. In gamma scanning the distribution of fission products is measured axially over a spent fuel elements. The axial shape which displayed on figure 2. are reflected the burn-up of the spent fuel as a function of position, using a slit width of 1 mm. The burn-up appears as a broad distribution peaking in the center and decreasing toward the fuel ends.

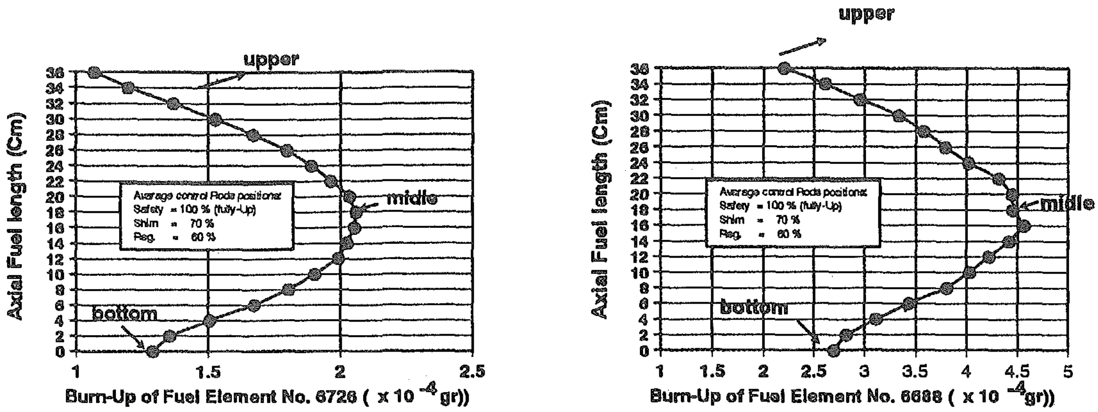

Figure 2 Axial Burn-up shape of two serial numbers of the KRR fuel elements

II.A.2. Identification of Corrosion Product from Cladding Materials

The corrosion product of fuel cladding SS-304 and Al-1100F type in the reactor core have been identified. By five hours reactor operation at a 100 kW power level, the ion exchange additional circulation is taken for analysis. Using gamma spectrometry techniques of the ion exchange resins the isotopes Mn^{57}, Cu^{67}, Zn^{69}, Cu^{66}, Zn^{65}, Mn^{56}, Mn^{57}, Mn^{58} , Al^{30}, Pb^{214} and Ni^{65}. It could be concluded that the fuel cladding is undergoing on corrosion process but how much the corrosion rate is not yet determined. It didn't find fission product isotopes which solute in the primary system[2]. The layout of detection systems is presented at figure 3.

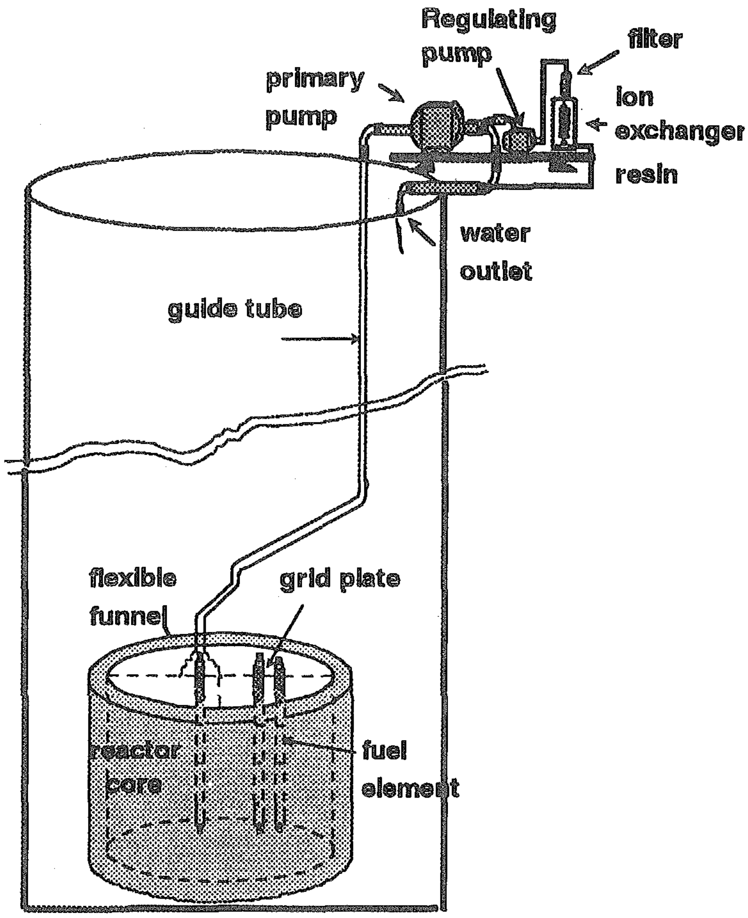

Figure 3 Schematic design of the KRR primary system water monitor

II. A.3. Visual inspection of cladding materials

Under Batan-US.DOE agreement regarding reexport Spent Nuclear Fuel (SNF), many requirements should be fulfilled and several tests should be performed. One of them is visual inspection by special camera underwater monitor. To fulfill that requirements, at June 1997 the inspection of 75 spent fuel elements which divided 65 are Aluminum type and the others are SS. type was done. The results can be concluded that all spent fuel elements are suitable to reexport to US-origin country. Detail result of visual inspection already presented at last Workshop on the Utilization of Research Reactor, Bandung Indonesia.

II.A.4. Neutron Radiography

The stationary neutron radiography system (SNRS) reactor is provided at radial beam tube. It is modified design for high-volume, large-scale, neutron radiography inspection of large parts such as mechanics engine and subassemblies. The SNRS design utilize one of four beam ports to transmit neutrons to special inspection bays where photographic and real time neutron radiography images are produced. Detail result of visual inspection already presented at last Workshop on the Utilization of Research Reactor, Bandung Indonesia.

II.A.5. Neutron Activation Analysis (NAA)

Application of NAA at the KRR is already reported at previously Workshop 1997, Bandung Indonesia. How ever, the utilization and optimization for NAA is not to much difference if compare with the last report which presented at last workshop in Bandung 1997. So that trough this opportunity, our report focused on Delayed Neutron Activation Analysis (DNAA).

Application of DNAA at 100 kW the KRR are almost to identify uranium ore at many location such as Kalimantan island. The result of application of DNAA to identify uranium ore is shown in table 2.

Table 2 Results display of part analysis by DNAA[8]

No	Serial No of Uranium ore	Total Count	Uranium Content (ppm)	No.	Serial No of Uranium ore	Total Count	Uranium Content (ppm)
1	PK-3	305	30.4272	11	KAL-27B	2066	142.2507
2	PK-4	190	23.6751	12	KAL-29	346	32.9884
3	PK-11	257	27.3782	13	KAL-34C	1938	134.2101
4	PK-27	146	20.3096	14	KAL-36A	22779	1457.5011
5	PK-44	140	19.9709	15	KAL-37C	26127	1670.5264
6	PK-51	100	17.3886	16	KAL-38B	804	62.1137
7	PK-55	439	38.9151	17	KAL-109	214646	3641.0807

8	PK-57	73	15.6741	18	KAL-117	2764	186.5949
9	PK-59	329	31.9301	19	KAL-118	7226	469.9194
10	PK-85	247	26.7654	20	KAL-119	2236	153.0484

II.A.6. Subcritical Assembly

It was amazing that in 1984 two superpower countries joined and sit together in the KRR. We call it the USSR subcritical assembly joint with US TRIGA reactor. At these facilities some topic of research on reactor theory i.e.; buckling measurement, neutron flux distributions, gamma flux distributions with different fuel configurations are already done. Since commissioning of subcritical assembly, already pass some graduate student and right now already working and doing some research activities on three research reactor in Indonesia i.e.; Yogyakarta Nuclear research centre, Bandung Research Centre as well as Multi purpose Reactor Centre of Serpong. Configuration of subcritical assembly as presented at figure 4.

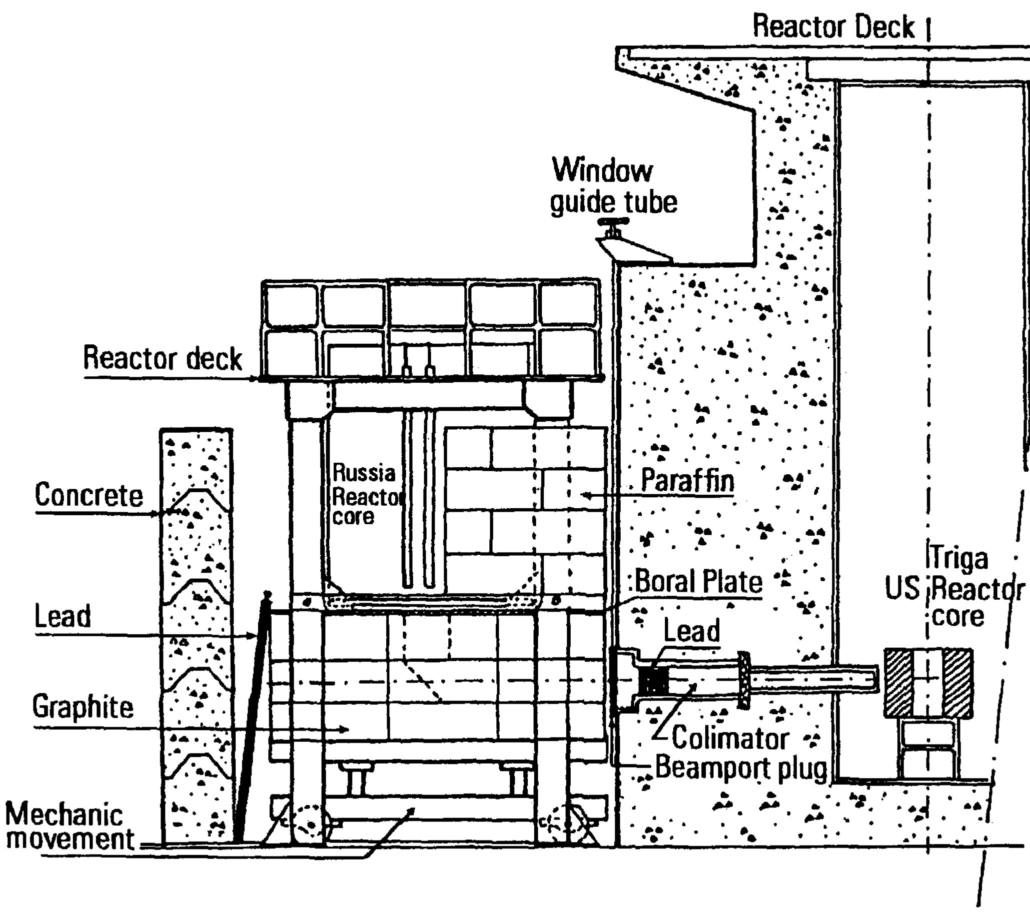

Figure 4 Configuration of subcritical assembly

III. THE FUTURE PLAN

In the previous section, it was found that the current status of the KRR and in this section we provide some explanations of KRR future plan briefly.

III.A. *Increasing power up to 250 kW*

Originally the KRR power level was designed up to 250 kW thermal. Due to some limitation i.e.; user demand and fuel capacity so that the power level of the KRR is still under power designed. According to power demand from some user and researcher, the increasing power in the future plan is very reasonable.

Some steps preparation to do it i.e.;

- To accomplish Standard Safety Analysis Report and preparation to submit to the Atomic Energy Regulatory Agency of Indonesia (BAPETEN)
- Visual inspection and Non Destructive Analysis (NDA) for some key component of the KRR i.e.; reactor tank, beam tubes, thermalising column, reflector, sit of reactor core, control rods, heat exchanger type shell-tube, primary and secondary pipes water and cooling tower. This inspection focuses to recognize that the components are still able or not to support the increasing power level planning for the future time.
- Providing some new fuel elements or using some old fuel elements for Bandung TRIGA Mark II 1000 kW. If we chose Bandung TRIGA fuels, we need visual inspection for some these old Bandung TRIGA fuels.
- Providing some primary and secondary cooling pumps as well as same additional heat exchanger.

III.B. Preparation to accomplish the conceptual design of the Boron Neutron Capture Therapy (BNCT)

The medical nuclear therapy in Indonesia was started at Yogyakarta Nuclear Research Centre (YNRC BATAN) which is introduces by the application of renograf. The renograf is one of some medical equipment's which is using to detect the function of kidney. Right now, these equipment's is already distributed to some center hospital in Java, Sumatra and Lombok east of Indonesia region. Trough the record operation of these equipment can be concluded that some patients choosing these method to recognize their kidney.

In the future, we try to provide prototype of BNCT facility at KRR. The reason of this study is supporting from our facility because the KRR is very suitable to provide thermal neutron flux around 10^9 n.cm^{-2}.s.$^{-1}$. Beside our facility, some hospital are interesting to develop the application of BNCT.

To prepare of the conceptual study we need some joints between researchers and institutions which have background in the BNCT.

IV. CONCLUSIONS

The KRR is still under utilized due to its facility is very limited. To improve their facility needed some promotion with related some researcher who have background on the neutron and gamma application to medical, agriculture, geological, industry and environmental fields. Beside these, the KRR should be consistent to provide high neutron flux. To accomplish that, it is very suitable to realize the increasing power level plan. However, to avoid any something wrong regarding the aging of some reactor component, the NDA requirements of these components should be fulfilled before increasing the reactor power level to 250 kW.

ACKNOWLEDGMENTS

The authors is indebted to some researchers and technicians at the KRR for kindly serving as the consultant and providing valuable guidance and advise of this paper.

The assistance provided by Dr. M. S. Suprawardhana is appreciated.

REFERENCES

1. Y. Sardjono, Syarip and E.T. Budisantoso; Handling and utilization of TRIGA Reactor Spent Fuel for a Gamma Irradiation Facility, International Conference on Radiation Protection in Nuclear Energy. Sydney, Australia, 18-22 April 1988.
2. Y. Sardjono, Syarip and M. Salman S.; Identification of Corrosion Product from TRIGA Fuels Cladding and Reactor Component, Second Asian Seminar on Research Reactors, Jakarta, Indonesia, 22-26 May, 1989.
3. M. Salman S., Syarip and Y. Sardjono; Operation Experiences of the Kartini reactor using Bandung Triga Mark II spent fuels, Humburg, 8-12 May, 1995.
4. General Atomics; TRIGA Reactors Safety, San Diego, California 92138 USA.
5. Eiji Sirai at all.; Clinical Experience of BNCT for Brain Tumors at JAERI.
6. Rolf F. Barth at all.; Boron Neutron Capture Therapy for Cancer, Scientific American, October 1990.
7. T. W. Tjiptono and Syarip; The Current Status of Kartini Research Reactor, The 1997 Workshop on the Utilization of Research Reactors, Bnadung Indonesia, November 6-13, 1997.
8. Syarip and Widi Setiawan; Ageing Investigation and Upgrading of Components/Systems of Kartini Research Reactor; The 1997 Workshop on the Utilization of Research Reactors, Bnadung Indonesia, November 6-13, 1997.
9. A. Soeleman at. all, Penentuan Kandungan Uranium Dalam Batuan Tambang Dengan Teknik Delayed Neutron Activation Analysis, Pertemuan dan Presentasi Ilmiah Jabatan Fungsional Pranata Nuklir; Yogyakarta Nuclear Research Center of BATAN, November 26-27, 1998