The current status of the internet reactor laboratory kartini research reactor for distance learning especially for higher education

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Abstract. The Kartini Reactor has been operating safely since March 1979 and has been used for research, education and training. Specifically for education and training, it has been utilized for online reactor physics practicum methods by utilizing the Kartini Reactor. This activity aims to enable students to learn and practice about nuclear reactors with distance learning methods, it adopts from the IAEA program under the name Internet based Reactor Laboratory (IRL). IRL is a physics reactor learning method using the internet that is used in distance learning with the reactor physics experiment guide (Protocol) which is already in regular practice (on site). IRL activities began in 2012 from the results of the reactor workshop at NCSU-America which has operated the IRL, then implemented at the Kartini reactor. IRL was first introduced at the International Youth Nuclear Summit in Jakarta in 2014 and introduced reactor operations to find out the dynamics of the operation of the Kartini reactor in collaboration with Adisutjipto College of Technology (STTA). Then continued collaboration between Center for Accelerator Science and Technology (PSTA) Yogyakarta, Center for Empowerment of Informatics and Nuclear Strategic Area (PPIKSN-BATAN) and Polytechnic Institute of Nuclear Technology (STTN-BATAN). Through the IAEA expert mission in 2017, the IRL system works properly, although limited in three protocols which are reactor operation, power calibration, and fuel temperature reactivity coefficient. The IRL program was last tested for distance learning for FMIPA-UGM students in 2019, it has shown a good performance and we agreed to continue the IRL program as one of the student practicum activities.

1. Introduction

The development of the Kartini reactor started at the end of 1974. The whole implementation of development was handled by Indonesian experts, in this case by (National Nuclear Energy Agency) BATAN, whereas in the implementation a group was given the duty for its implementation and called the Reactor Development Team which was formed in accordance to the Letter of Decision of the Director General of BATAN No. 119/DJ/13/XI/1974 dated 13 November 1974. The Kartini reactor had reached its first criticality condition on Thursday 25th January 1979 at 17:40, and inaugurated on 1st March 1979 by the President of the Republic of Indonesia which at that time was Mr. Soeharto. The main function of Kartini reactor is for research, irradiation, education, and training of cadres in the reactor field. The operation was conducted at a power level of 100 kW [1]. The reactor operation has been carried out at a 100 kW power level in accordance with the operating license of (Nuclear
Energy Regulatory Agency) BAPETEN with a maximum designed power for 250 kW and the reactor has been operating by request and it is ready to operate 6 hours/day.

The Education and Training Program is carried out to fulfill the nuclear reactor regulations from Bapeten, which is reactor operation training for operator and supervisor, and reactor maintenance for technician and supervisor in order to get licenses from BAPETEN. Furthermore, education and training programs are implemented in several events such as reactor workshops, "On the Job Training" (OJT), Nuclear reactor schools etc. Presently, the Kartini Reactor has been used as a practical and exercise reactor by various students from several universities such as STTN, UGM, UNY, UI, UNS, SWCU, UNDIP, UNES, UNS, UNSOED, etc and several universities also included this program in their curricula. Regarding "on site" education, Kartini reactor has prepared 8 learning protocol guiding packages as desired by stakeholder such as Practicum Start up and Operation, Fuel Temperature Reactivity Coefficient, Criticality, Control Rod Calibration, Power Calibration, Neutron Flux Measurement and Neutron Spectrum Analysis, Gamma Scanning, and Delayed neutron Fraction. In addition, the Kartini reactor also has a short course program as a Nuclear Reactor School for 2-3 days for an introduction to Nuclear Reactors especially for university students, nuclear community student organizations and also lecturers of various universities.

The Kartini Reactor has prepared a strategic plan in accordance with IAEA-TEC.DOC-no.1212 "Strategic Planning (SP) for Research Reactors" 2015-2019 which is used as a guide for activities and was revised in 2018 with reference to IAEA-NG-T 3.16, PSTA SP documents 2015-2019, BATAN SP documents 2015-2019, IAEA NES No. NP-T-5.3 "Applications of Research Reactors" 2014, LAK Rev 7 2012 documents and addendums. It has been presented on workshop in Vienna Austria [1].

In accordance with the development of information technology and preparation for the construction of a Power Reactor or PLTN, the IRL program is an opportunity in developing national and even regional education so an internet-based reactor laboratory (IRL) was developed. The Internet Reactor Laboratory (IRL) is a learning tool on reactor physics laboratory using internet which is usually used in a distance learning through websites and video conferences (teleconferences). At present, internet technology is very easily accessed through internet service providers (ISPs) which make it possible to utilize online / internet media as a learning method which is a trend. The Internet Reactor Laboratory program is one of them, which is currently being developed by PSTA-BATAN, which is supported to provide technology learning media, especially nuclear reactors, through internet facilities that are preferred for physics reactor students that have been developed by the IAEA [2]. The International Atomic Energy Agency established its Internet Reactor Laboratory (IRL) program as one solution for a country that has a research reactor to provide practical reactor operating experience to nuclear engineering students, usually but not always in IAEA member states that do not have a research reactor [3].

The Kartini reactor Internet Reactor Laboratory project adopted the IAEA Program which was started at NCSU (North Carolina State University) with a PULSTAR research reactor that has been operating since 2010. The IRL activity was carried out in collaboration with BATAN-IAEA, and BATAN has received assistance from IAEA Expert from Argentina related to the TC-IAEA 2018-2019 program which provides an opportunity for several staff to learn about IRL activities in the ISIS-France Reactor in 2018.

Indonesia is the largest archipelago in the world bordering Malaysia on the north of the island of Borneo, Papua New Guinea on the east of the island of Papua and East Timor on the north of the island of Timor. Indonesia is the largest archipelago country in the world, with more than thirteen thousand islands, with an area of 1,904,569 square kilometers with a population of 234,693,997 [4]. Based on the above reasons, the IRL is suitable to be applied as a medium of learning about nuclear physics through web-sites and teleconferences so that distance problems are no longer a problem. The IRL is intended to increase global knowledge about nuclear education based on the use of research reactors. It can also offer additional options for accessing operational research reactors worldwide and conducting education and training activities via the internet. The IRL project is basically aimed at undergraduate or graduate students [5].
The IRL aims to provide digital data access needed to conduct reactor physics experiments that have internet-based access and they can communicate interactively both via the web and teleconferencing. This method can be disseminated knowledge about nuclear technology, especially reactor physics by utilizing the Kartini Reactor as a learning facility in distance education and training, without coming to the location of the Kartini Reactor facility and this activity has been successfully carried out properly as planned [6].

2. Internet Reactor Laboratory Concept

The IRL program was first started with collaboration between BATAN / PSTA and STTA to implement the results of the workshop with an topic "on Secure Operations and Applications at Research Reactors". Hosted at North Carolina State University, Raleigh, North Carolina, USA, 29 October - 2 November 2012, to be adopted in Indonesia, and previously Reactor Division had carried out various Education & Training programs such as "experiments and exercises" at the Kartini reactor laboratory for various institutions/universities. Through this IRL project, it is hoped that geographical problems will not become obstacles in being able to learn and understand reactor physics learning for students at universities located far from the Kartini reactor location, even the Asia Pacific region.

The reactor physics experiments and exercises were carried out by "operators and supervisors" of operations, who had been licensed from Bapeten at the Kartini research reactor facility. The experimental results are displayed online in the form of graphic data or reactor operating parameter data with direct explanation via teleconference and website. The first concept of IRL is illustrated in Figure 1.

![Figure 1. Illustration of IRL Kartini Reactor concept.](image)

IRL completeness includes teleconference system and software for data acquisition systems. The data of reactor operating process parameters can be visualized at the same time (real time) at the time of reactor kinetics experiment. To participate in the IRL, the institution that wishes to utilize the research reactor should have two things: teleconference equipment and data acquisition software. The atmosphere and situation of the main control room, operating data and experiments can be displayed in the classroom by the instructor as a user through the software and delivered to the student. Instructor as a class informer (lecturer) can explain parameters data (process operation and or experiment) to the audience (student). Monitored data can be collected through existing data base so that it can be displayed and repeated as necessary [7].

IRL is mainly intended for nuclear engineering and nuclear physics students, who otherwise would not have an opportunity to get insight into the practical aspects of reactor physics and its operation. IRL experiments and exercises can also be tailored for nuclear professionals. The IRL works by giving access to view reactor experiments via an internet link. Using hardware and software installed in a research reactor in the host state, information is sent over the internet to the guest institution, where a real-time display of the reactor’s control room is visible to students. Using video conference equipment, students at the guest institution can interact with lecturers and operators in the reactor control room and direct the lecturer of the host reactor to conduct practical experiments [8].
The implementation of IRL Kartini reactor concept by Principles of operating and/or experimental data parameters from NTC and data base self are made through a switching hub connected to the router and together audio/visual information from the camera IP can be sent to the client PC through the router as an IRL service over the internet [7]. Figure 2 shows the IRL system network of Kartini research reactor, which is similar to the IRL system network of reactor RA-6 CNEA-Argentina as shown in Figure 3. Figure 4 shows the instructor-student-operator interaction process as a practical way of querying the data parameters of the reactor and or experimental operation.

**Figure 2.** The IRL system network of Kartini research reactor [7].

**Figure 3.** The IRL system network of reactor RA-6 CNEA, Argentina [9].

**Figure 4.** Interaction of relationship between student, classroom instructor (lecturer) and reactor operator on Kartini research reactor [7].
3. The status of IRL Kartini Reactor research

At the beginning test for the first trial using existing data acquisition, it can be displayed well but still limited to several parameters. Eventually, the IRL system has been successfully tested on the soft launching was held during the Nuclear Youth Summit in Jakarta on November 22, 2014. Figure 5 shows the appearance of the IRL at the Kartini reactor operation for the first performance and Figure 6 shows some moments at the event as a manifestation of IRL’s first performance. The host gives an explanation regarding IRL and limited explanations about the operation of the Kartini research reactor.

![Figure 5. The first performance IRL at Kartini Reactor.](image)

![Figure 6. The event as a manifestation of IRL's first performance.](image)

The IRL system has been successfully tested, and the soft launching was held during the Nuclear Youth Summit at Royal Kuningan Hotel, Jakarta on November 22, 2014. Figure 6 shows some moments at the event as a manifestation of IRL’s performance. The explanation is performed to display the IRL website by describing what is IRL, how reactor operation practice, preceded by check
list information for start-up of Kartini reactor operation. The reactor operation is shown by teleconference for the interactive process while the IRL website shows the operation process by displaying the position of the control rod and reactor power. The operator in the main control room can explain the ongoing process in the reactor power operation after the check list for the start-up is completed by the operator on duty. The reactor operation has taken place according to the required critical power level at 100 kW.

The instrumentation and control system was upgraded in 2016, using compact RIO or cRIO instruments. The cRIO is an industrial computer technology developed by the National Instruments Company. It is used as a data acquisition and control in a system by adding modules as needed [10]. The Data acquisition parameters can be displayed properly in collaboration with STTN meanwhile, the IRL website display programs including internet network facilities in collaboration with PPIKSN. Figure 7 shows the Kartini Reactor parameter monitoring display performance after upgraded.

4. Result and discussion
The Internet Reactor Laboratory Projects of Kartini Reactor has been successfully built and tested in good collaboration with STTA, STTN, PPIKSN and expertise by IAEA, as an education and training program related to learning physics of the reactor, by online methods. In principle all laboratory exercises related to reactor physics in the Kartini Reactor can be done through IRL, but currently only 3 experiment protocols guidelines that can be accessed using IRL, that are reactor operation experiment, power calibration, and experiment of temperature coefficient of the fuel [11].

On the IRL website, the 3rd laboratory exercise can be accessed on the menu (Practice 1, Practice 2, and Practice 3) and all of the parameter data experiment will record on this sub menu and the data in experiment can be accessed via the IRL web in the sub menu too. The menu contains sub-menus "Online Practice", "Experiment Data" and "Data Downloads". Sub menu "Online Practice" contains the explanation of the laboratory exercise, procedures and data download form. Sub menu "Experiment Data" contains data of Kartini reactor parameters that are displayed in real time. While in the sub menu "Data Download" contains parameter data from the operation of the Kartini Reactor which is presented in the form of excel. The display can be seen as in the figure 8.
Figure 8. IRL website display.

Figure 9. The practice and exercise trial of IRL with students of FMIPA UGM.

FMIPA-UGM students study the reactor physics on their campus, online with the Kartini Reactor while the reactor is in an operating condition overseen by a lecturer from the FMIPA-UGM and guided online by officers from Kartini PSTA-BATAN Kartini Reactors, as shown in the Figure 9.

5. Conclusion
Internet Reactor Laboratory (IRL) of Kartini Reactor Project has been successfully operated and tested in collaboration between PSTA and STTA, STTN, PPIKSN and also with IAEA assistance. The IRL is an education and training program mainly related to physics reactors, through websites and teleconferences, thus enabling interactive communication. Currently, the IRL system limited to three protocol guidelines for practical and exercises of nuclear reactor physics: Reactor Operation Kartini, Reactor Power Calibration, and Fuel Temperature Coefficient.

The IRL kartini website can be accessed at http://irlkartini.batan.go.id, and it is opened to all parties who are interested in reactor physics either in Indonesia or abroad. Universities or research
institutions that want to officially access the IRL site require to have an MOU with PSTA, prepare the teleconference device with a minimum bandwidth of 2 Mbps, and also an Internet network to view the websites, download data files, etc.

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