EDUCATIONAL PROGRAMMES IN MARIA REACTOR

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ABSTRACT

MARIA reactor, located in National Centre for Nuclear Research is the only operating research nuclear reactor in Poland. That, combined with the existence of several physics and nuclear engineering faculties makes MARIA the unique facility not only for research and radioisotopes production, but also training of students end education of general public. We provide lessons on different levels of advancement: from reactor tours and lectures for high schools to specialized courses for graduating students. The reactor and her crew, under an agreement with universities, conducts practical lessons of nuclear physics on variety of topics, for example activation analysis and dosimetry. We do not limit our activities to courses, but provide graduating students the, unique in the Polish conditions, possibility of writing a bachelor and master thesis during the internship in the nuclear research reactor. We cover variety of topics from neutron physics to thermal hydraulics, providing students with experience and possibility of data acquisition from working nuclear reactor. This paper provides the summary of MARIA's crew experience in educational activities, our student classes' programme and future plans.

1. Introduction

MARIA is a pool type, water cooled reactor located in National Centre for Nuclear Research (NCBJ) in Otwock-Świerk, near Warszawa – capital of Poland. MARIA is a multipurpose research reactor, especially dedicated to radioisotopes production (including Mo-99), material testing, radiography and research in neutron physics. Her most important operational parameters has been compiled in table 1.

Since her initial criticality in 1974, one of the important scientific tasks of the reactor is providing knowledge and education alike to students, specialist, and general public. This paper concentrates on our educational programmes addressed to university students and high school pupils. All of the educational activities mentioned in the paper are performed either by the Reactor Crew or Education & Training Division (specialized educational branch of NCBJ).The following sections of the article will concentrate on school field trips, laboratories for students, and possibilities for writing student projects and masters theses in MARIA facility.

type	fuel channels in pool
nominal power	30 MWth
thermal neutron flux	$2.5 \cdot 10^{14}$ n/cm^2/s
moderator	H_2O, beryllium
reflector	graphite in Al.
fuel enrichment	19.7/19.75% ^{235}U

Tab 1: Key operational parameters of MARIA reactor

2. Lessons and visits to the reactor

This activity, addressed not only to schools, but also to the general public is performed by NCBJ Education & Training Division. Each year, MARIA is visited by c.a. 7000 people.

During the tour they are provided with basic knowledge about nuclear reactors with particular emphasis on operation, construction and use of research reactors. Also lectures on various branches of nuclear physics and medicine are available.

It's worth to note that besides lessons and tours to the MARIA reactor, Education & Training Division organizes also physics laboratories that covers wide range of topics, from nuclear radiation dosimetry and nuclear particle physics (eg. Rutherford experiment, Franck-Hertz experiment).

3. Laboratories and lectures for students

MARIA reactor, under an agreement with two Polish leading universities (Warsaw University of Technology and University of Warsaw), is providing laboratories regarding nuclear reactor physics to student as a regular class in their study programme in field of nuclear physics or nuclear power engineering. Apart from those two cases we also, on request, host students from different universities.

Laboratory takes whole day and consist of multiple exercises from nuclear reactor engineering and a dedicated tour to a reactor. Its timetable is adjusted to reactor operation schedule. The scope of laboratories is presented in sections below

3.1 Measurement of neutron fluxes in nuclear reactor

This activity teaches students about fluxes and spectra of neutron in nuclear reactor together with the characteristics of the local parameters dependent on eg. position in core or self-shielding effect. The theoretical knowledge about activation detectors as measurement method is given together with computation algorithms that are used pending the processing of measuring results of the neutron fluxes.

Practical part consists of calibration of the HPGe detector with calibration source. After that the activation foils (^{198}Au, ^{60}Co, and ^{58}Co) are measured. Based on their activities, with the knowledge from the theoretical lecture, the reaction rates (n,p and n,γ) are calculated, followed by neutron flux density calculation. The exercise is performed separately for the two cases: fast neutron flux measurement and thermal + epithermal.

3.2 Reactivity measurement in nuclear reactor

That exercise starts with theoretical lecture about point kinetics model of nuclear reactor's reactivity. The topic is broadened with the information about the effect of finite operation time of a nuclear reactor, the effect of a neutron source, and temperature effect on reactivity. Finally the necessity of reactivity measurement together with measuring techniques presented.

Practical part of this exercise consists of control rod drop experiment and period measurement. Students are present in the control room and observe the whole procedure performed by the reactor crew, while the explanation is given to them. After the experiments they are given the data produced during them and have to calculate the reactivity on the basis of nuclear reactor power changes, and draw the S-curve of the measured control rod.

3.3 Measurement of the radioactive releases from the nuclear reactor

During this exercise, students learn about radioactive releases of noble gases from nuclear reactor and way of measuring them. They also get the knowledge about multiple-barrier system that protects humans and environment from radionuclides produced in nuclear fuel.

Additionally, the model of Xenon-135 and 135m releases and migration through the safety barriers in MARIA reactor is presented.

In the practical part, students learn how to calibrate HPGe detector and perform this activity. Then they on their own, measure activity of air sample containing noble gases: ^{41}Ar, ^{85m}Kr, ^{88}Kr, ^{135}Xe and ^{138}Xe. The exercise is concluded by calculating the time of release and comparing measures activities with safety limits.

4. Science projects and Master theses.

We, as a part of the biggest nuclear institute in Poland enable students to write their theses in our MARIA reactor. Unfortunately, due to staff number limitation we cannot provide this possibility to many of them, but in this case the quality makes up for quantity. We cover broad area of topics from relatively simple measurements (eg. temperature coefficient of reactivity) to fairly complicated topics like possible seismic impact on nuclear reactor. Students could perform their own experiments with our measurement tools and write their theses under supervision of nuclear specialists.

5. Summary

The educational activities presented above provides the knowledge about the nuclear reactor to both the general public and nuclear physics / nuclear power engineering students. For both this groups they are the unique in the Polish conditions possibilities to experience and learn about nuclear reactors. The knowledge provided is adjusted to the needs of the visitors groups. General public, eg. high school pupils, gets the knowledge about benefits to the society provided by the nuclear reactors, together with basic knowledge from nuclear physics and radioprotection. The offer addressed to students is much more specialized and provides them with knowledge and practical skills necessary in future career in nuclear science or industry.

Both of the educational activities are equally valuable to the society:
Nuclear specialists more and more depends on simulation, sometimes during their career they do not see nuclear reactors with their own eyes, so the possibility of perform actual measurements by their own hands, when they start their career cannot be underestimated.
In case of general public, to learn is the first step to accept, so fair education about nuclear reactors provides the possibility to base their judgements on reality, not the heard rumours. It seems to be particularly important in the late modernity of post-truth, when the debate is more and more based on emotions, not actual data: it is our small contribution to change it.

References

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