Thermal Power Calibration And Neutron Flux Measurement Of The Nuclear Research Reactor IAN-R1 2015

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Abstract. This paper describes the thermal power calibration and neutron flux measurement performed in order to have an approach to the IAN-R1 reactor core characterization in the framework of the recently acquired operating license for five years.

Key Words: Power calibration, neutron flux.

1. Introduction

The IAN-R1 is a conversion reactor located in Bogotá Colombia, it was initially fueled with MTR-HEU enriched to 93% U-235 operated at 10 kW since 1965, it was upgraded to 30 kW in 1980. In 1992 General Atomics (GA) upgraded the Instrumentation and Control I&C, so, in 1997 GA achieved the conversion of HEU fuel to LEU fuel TRIGA type, and upgraded the reactor power to 100 kW but it is operating actually to 30 kW for radiation safety, then the reactor was brought into an extended shutdown condition from 1998 to 2005. In 2005 was necessary the development of a recommissioning program that should repeat the results of the commissioning tests conducted in 1997.

The Instituto Nacional de Investigaciones Nucleares (ININ) from México, upgraded the Instrumentation and Control I&C in 2012, and the reactor got up in 2014 a license for operate to 30 kW along 5 years.

2. The IAN-R1 Reactor

The reactor IAN-R1 is a swimming pool type with concrete shield and two beam ports. The fuel (U-ZrH1.6) is contained in 4-rod clusters. The core configuration is a rectangular grid plate that holds a combination of 4-rod and 3-rod clusters. The 3-rod clusters provide a fourth cluster space to be used either for in-core irradiation or control rod locations. The core contains 50 fuel rods, 3 control rods and 3 in-core water filled experimental locations. Figure 1 presents the top view of the core. The assembly is located inside an open tank full of light water which acts as biological shielding, partial neutron moderation and core coolant. The reactor core is cooled by natural circulation. The tank water is cooled by the primary and secondary systems.

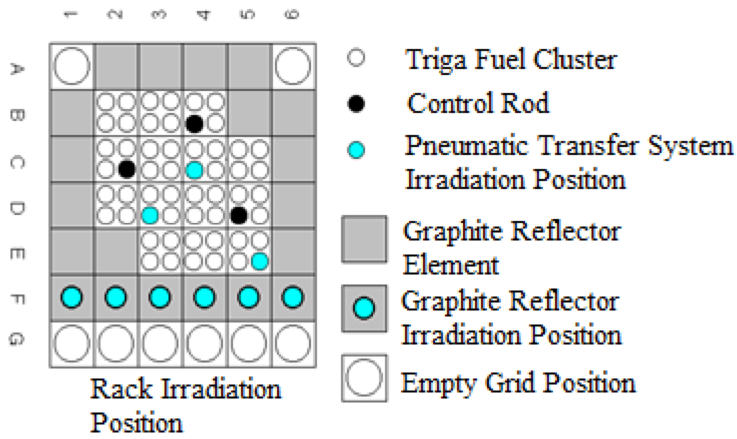

Figure 1. Top view of the IAN R-1 Core

3. Thermal Power Calibration

Before this calibration the reactor pool was thermically isolated. The reactor was operated at approximately 20 kW, indicated in the console, during about 4.5 hours, with manual power corrections, and with the forced refrigeration off. During the calorimetric experiment, all the pool temperatures were collected manually in intervals of 15 minutes, and the pool measurement was performed with RTD sensors separated 0.5 m from the core and 0.5 m in between them, Figure 2 shows the thermocouples positions in the pool and the pool water temperature increase during the thermal power calibration in the Figure 3 [1].

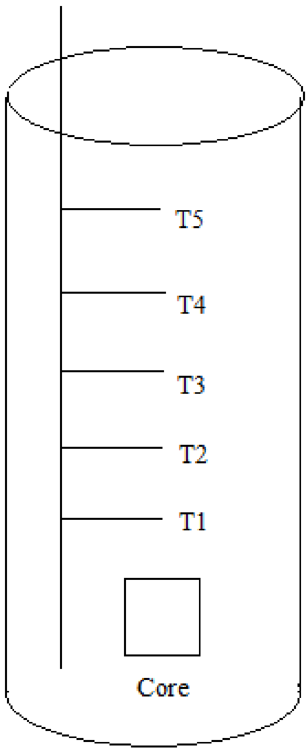

Figure 2. Thermocouples positions in the pool

At 20 kW the radiation level was smallest than one obtained during Power Calibration experiment performed in 2008 [2], indicating that the real power could be smaller. It was determined that the real reactor power was 17.15 +/- 0.39 kW. With the reactor at 20 kW, the positions of the two fission counters and ionization chamber were adjusted in order to obtain the correct console indication of the power (17.15 +/- 0.39 kW).

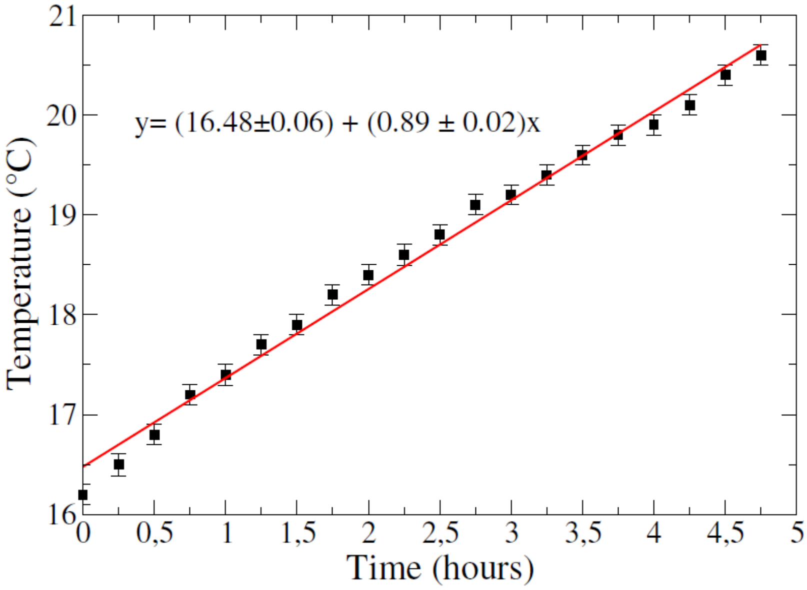

Figure 3. Pool water temperature increase during the thermal power calibration

4. Neutron Flux Measurement

The spatial neutron flux was measured axially in the clusters F1, F2, F3, F4, F5, F6 *(Figure 4 to Figure 9)* and rack irradiation at the midpoint on row G between positions 3 and 4 *(Figure 10)* with an uncertainty of 12%. The spatial distribution of thermal neutron was determined using a vanadium self-powered detector, this flux it was used to irradiate the samples and standards the Laboratory of Neutron Activation Analysis (NAA) of the Colombian Geological Survey who radiate samples in this reactor during the first round of proficiency testing Wageningen Evaluating Programs for Analytical Laboratories (WEPAL) received in 2015.

The proper calibration of reactor power and flow measurement of thermal neutrons has been demonstrated in the good performance obtained in the WEPAL proficiency testing.

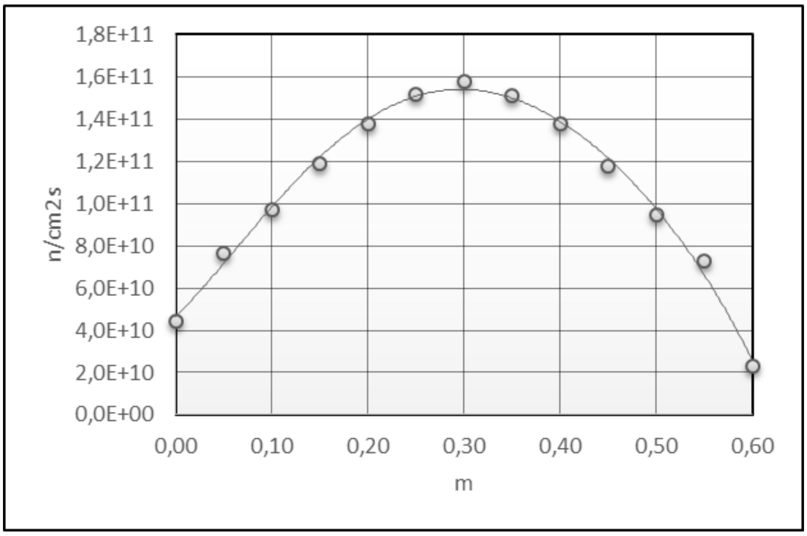

Figure 4. Axial thermal neutron flux F1

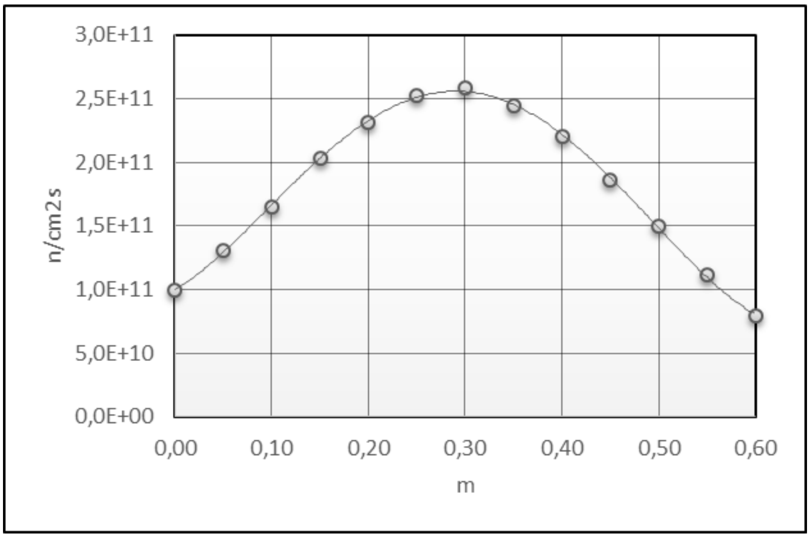

Figure 5. Axial thermal neutron flux F2

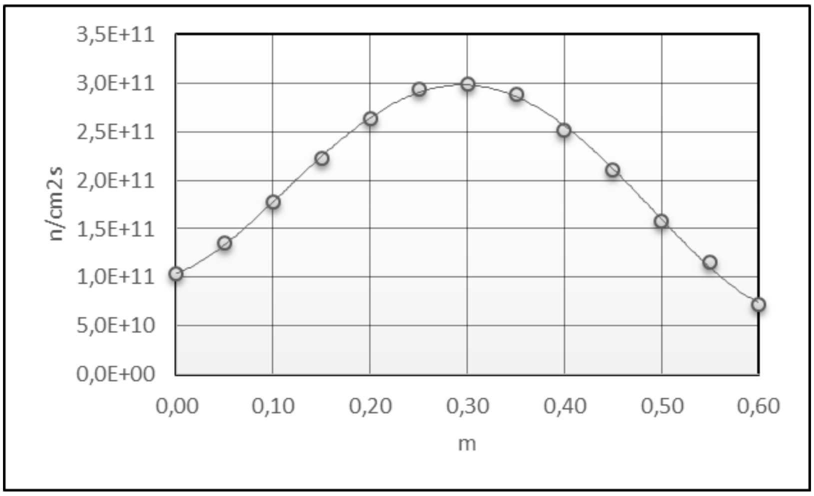

Figure 6. Axial thermal neutron flux F3

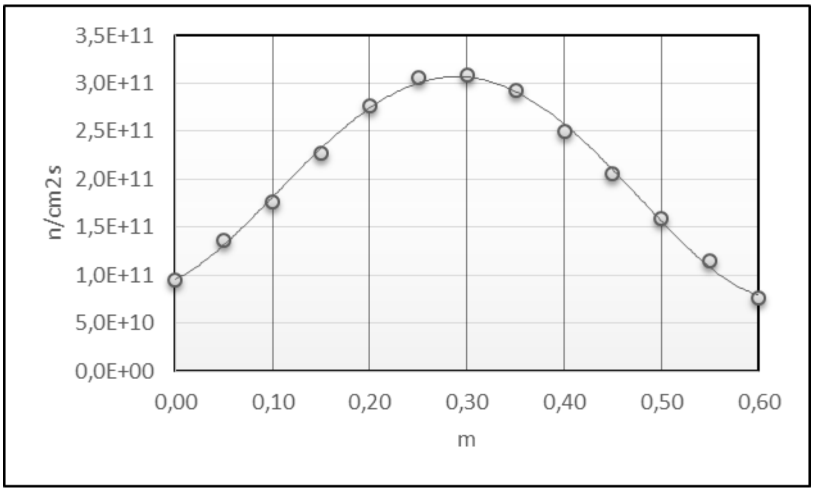

Figure 7. Axial thermal neutron flux F4

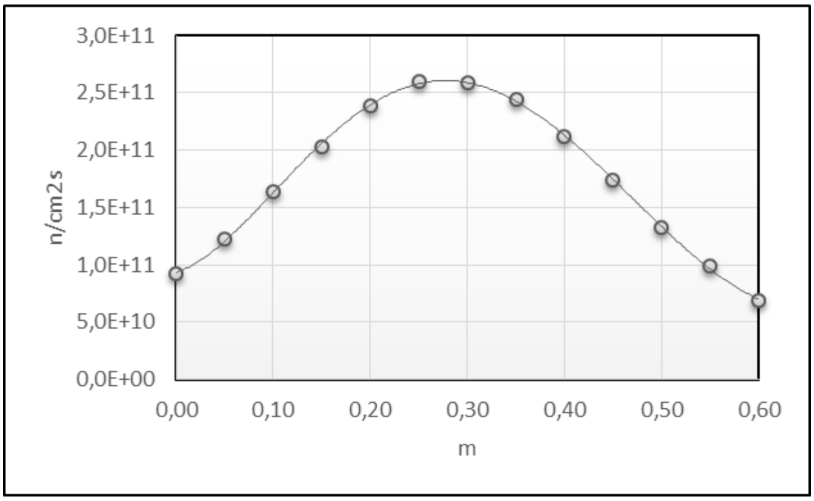

Figure 8. Axial thermal neutron flux F5

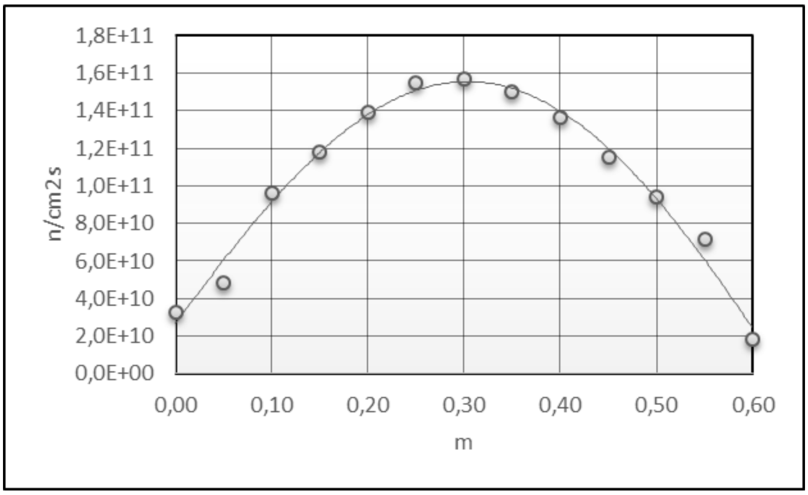

Figure 9. Axial thermal neutron flux F6

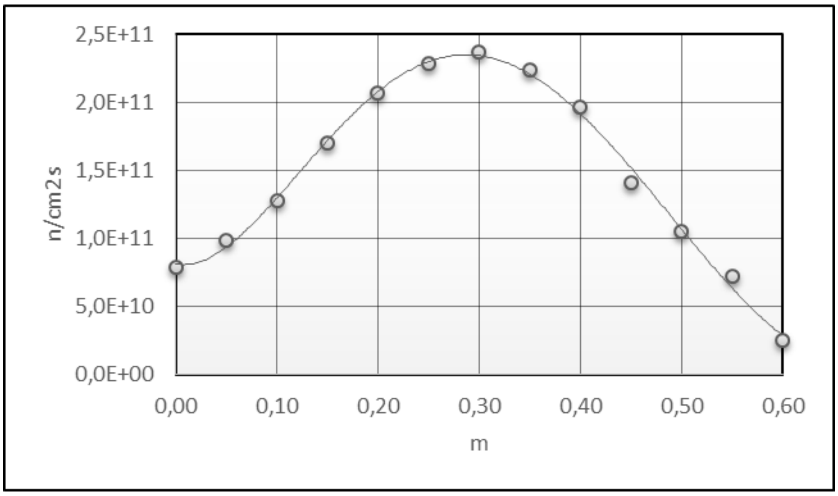

Figure 10. Axial thermal neutron flux at rack irradiation position

5. Conclusion

The thermal power calibration that was performed using the calorimetric method adopted in the TRIGA IAN-R1 Reactor enabled determination of thermal neutron flux measurement commensurable with international pairs. This has been demonstrated in the good performance obtained by the Laboratory of Neutron Activation Analysis (CGS) who radiate samples in this reactor during the first round of proficiency testing Wageningen Evaluating Programs for Analytical Laboratories (WEPAL) received in 2015.

6. References

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