CHARACTERIZATION OF THE NIGERIA RESEARCH REACTOR-1 LEU FUEL USING SCALE 6.2.3 TO SUPPORT FUTURE SPENT FUEL MANAGEMENT PLANS

SPANS

SYMPOSIUM ON PLASMA AND NUCLEAR SYSTEMS (SPANS-2024)
Ontario Tech University, Oshawa, ON, Canada
20-Aug-2024

Dr. J. Simon
Ahmadu Bello University, Zaria/National Open University of Nigeria

E-mail: sjkahugu@yahoo.com
Twitter: @sjkahugu1
Tel: +2348034383802

OUTLINE OF PRESENTATION

Introduction: Description of NIRR-1, Importance of characterization

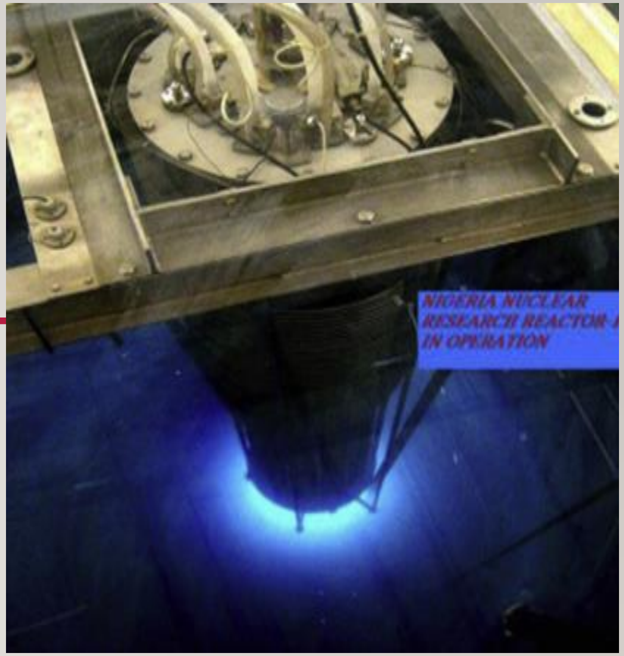
Methodology

Results

Conclusion

INTRODUCTION

- **Description of NIRR-1**
  - It is a Miniature Neutron Source Reactor (MNSR) designed and deployed in several countries by the China Institute of Atomic Energy (CIAE).
  - Located at the Centre for Energy Research and Training (CERT), Ahmadu Bello University Zaria Nigeria
  - Its first criticality was achieved in February 2nd, 2004.
  - Initially fuelled with HEU (90.2 % of U-235) and operated optimally at a full and half power of 30 kW and 15 kW respectively
  - Converted to LEU (13 % of U-235) fuel in 2018 and currently operating safely at full and half power of 34 kW and 17 kW respectively



NIRR-1, a tank-in-pool light water reactor

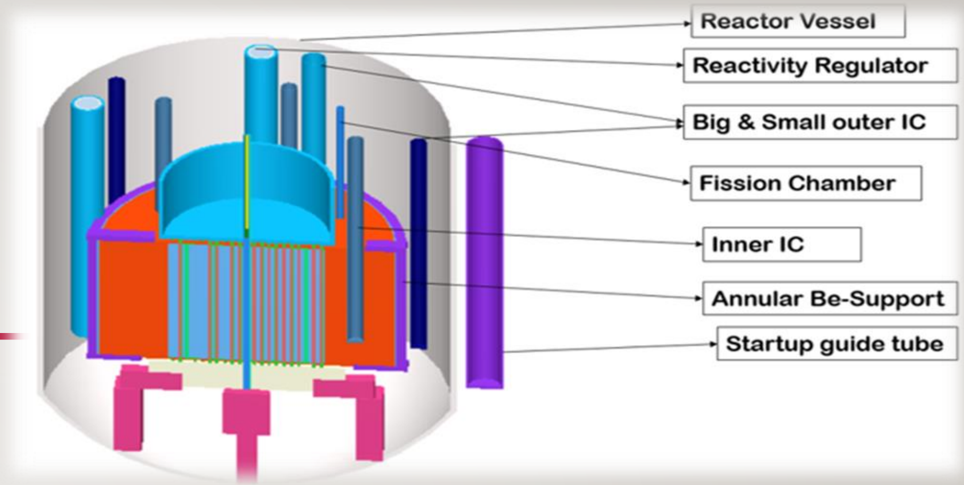
- Importance of Characterisation:

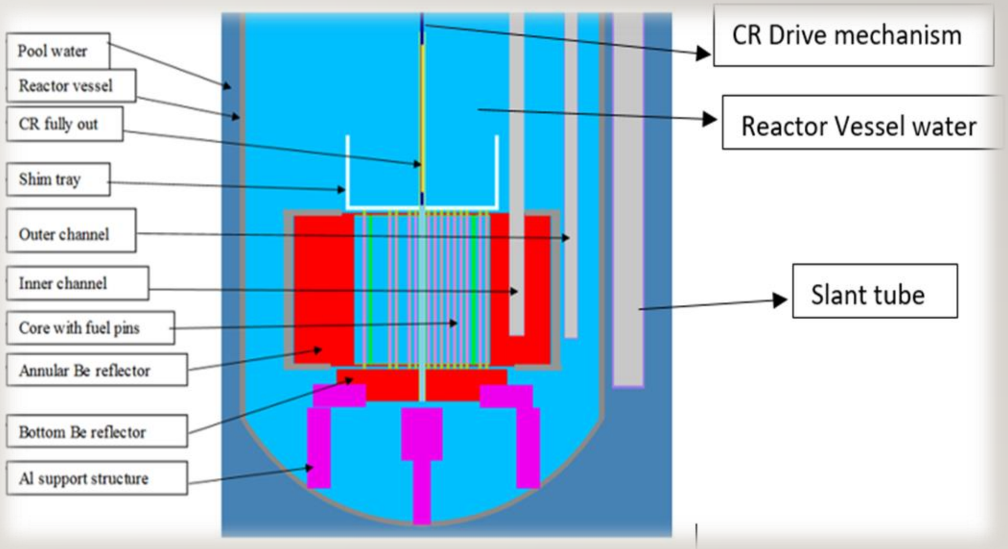
  - The initial loading in the LEU core was: 1406.10 g of U-235 (13% of U in UO2 fuel) and 9035.95 g of U-238 (87% of U in UO2 fuel)
  - In comparison to the HEU core loading of 1006.65 g of U-235 (90.2% U in the UAL4 fuel), more yield of Pu-239 and other actinides were expected to be higher in the LEU core.
  - This underscore the need to used computational tools to model and estimate the core inventory at the of its lifetime
  - Characterization of the spent NIRR-1 LEU core is key to decision making with respect to emergency response plan, decommissioning plan, spent fuel storage, transport and management plan.

METHODOLOGY

- To achieve a reliable reactor fuel characterization, Monte Carlo N-Particle (MCNP) and other Monte Carlo-based codes have been very instrumental.
- In this work, SCALE 6.2.3 code was used to model NIRR-1, and KENO-VI module was used to perform the criticality calculations.
- KENO is a three-dimensional (3D) Monte Carlo criticality transport program developed and maintained for use as part of the SCALE Code System.
- ORIGEN module of SCALE code was used for fuel depletion
- The Output from ORIGEN was selectively displayed for actinides of interest using Opus module

- The 3D model of NIRR-1 was created with KENO-VI by defining all the component of the reactor explicitly
- TRITON depletion sequence (T6-DEPL) which couples KENO-VI and ORIGEN was used to perform the reactor core depletion
- The effectiveness of the model was tested by benchmarking with some measured parameters of the reactor.
- The depletion was performed at full power of 231.931 MWD/MTU for 918 FPEDs at an operational regime of operating 3 hours per day, 3 days per week, and 48 weeks per year





- KENO-VI code was executed using the following computational parameters specifications:
  - gen=1000
  - flx=yes
  - npg=100000
  - nbk=125000
  - nsk=50
  - sig=0.00005

RESULTS

The inventory of some selected actinides products from the depletion of NIRR-1 are presented in the table below

Actinides	Inventory (grams)
U-233	1.24E-04
U-234	2.49E+03
U-235	2.60E+05
U-236	1.89E+03
U-238	1.74E+06
Pu-239	4.72E+00
Pu-238	2.34E-06
Pu-240	2.75E-04
Pu-241	4.75E-08
Np-237	5.88E-02
Am-241	3.39E-10

Estimated total decay heat
At the end of core life:

1782.17 W

CONCLUSION

- The inventories of Pu-239 and other actinides are not substantial enough to present high safety risk during spent fuel management processes.
- However, this estimation provides some insights into what stakeholders should expect at the end of the core lifetime.
- The characterisation provided an estimated decay heat which is very essential for the design of storage and/or transportation cask

QUESTIONS??