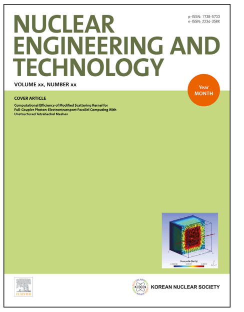
Accepted Manuscript



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Z. Nasr, R. Salimi, A. Askari, J. Khorsandi, M. Mirvakili, M. Mashayekh

PII: S1738-5733(16)30105-X

DOI: 10.1016/j.net.2016.07.004

Reference: NET 238

To appear in: *Nuclear Engineering and Technology*

Received Date: 20 December 2015

Revised Date: 4 May 2016

Accepted Date: 1 July 2016

Investigating HWZPR with a new core configuration based on experiment and calculation results

Z. Nasr *, R. Salimi, A. Askari, J. Khorsandi, M. Mirvakili, M. Mashayekh

Reactor Research School, Nuclear Science and Technology Research Institute, Atomic Energy Organization of Iran, P.O.Box 81465/1589, Esfahan, Iran.

Abstract

The Heavy Water Zero Power Reactor (HWZPR), which is a critical assembly with maximum power of 100 Watts, can be utilized in different lattice pitches. The last change of core configuration was from a lattice pitch 18 cm to 20 cm. Based on the regulation [1], before the first operation of the reactor, a new core was simulated with MCNP-4C and WIMS-CITATON codes. To investigate the criticality of this core, the effective multiplication factor (K_{eff}) versus heavy water level, and the critical water level were calculated. Then for safety considerations, the reactivity worth of D_2O, the reactivity worth of safety and control rods and temperature reactivity coefficients for the fuel and the moderator, were calculated. The calculated results show that the relevant criteria in the safety analysis report (SAR) were satisfied in the new core. Therefore, with the permission of the reactor safety committee, the first criticality operation was done and important physical parameters were measured experimentally. The results were compared with the corresponding values in the original core.

Key Words: Criticality assembly, MCNP, WIMS, CITATION, Safety, Heavy Water, Zero Power, Lattice Pitch

1. Introduction

In HWZPR, natural metallic uranium is used as a fuel, heavy water as a moderator and graphite as a radial reflector. The reactor is provided with safety rods, control rods and an emergency dump system. The reactor is located in the reactor research school of Esfahan, Iran. There are two pairs of top and bottom grid plates, which can form four lattice pitches. The first pair of grid plates form square lattice pitches equal to 20 cm and 14.14 cm, and the second one forms lattice pitches equal to 18 cm and 12.73 cm. The reactor has been operating in 18 cm lattice pitch with maximum 124 fuel rods until now. For this core configuration, different physical parameters have been measured. In order to study the physical parameters in other lattice pitches, the lattice pitch of the core was changed to 20 cm. In this case, the maximum number of fuel rods in the core is equal to 112. Since the lattice pitch was changed, first of all, the possibility of criticality of the new core should be verified. According to SAR, near critical state, the reactivity insertion rate in the core should not be more than 2×10^{-4} ($\Delta k/k$)/sec, the reactivity worth of each safety rod should be more than 1% $\Delta k/k$ and the reactivity worth of each control rod should be less than 0.2% $\Delta k/k$ [1]. Therefore, before first start up, the effective multiplication factor, the critical water level, the reactivity worth of heavy water, the reactivity worth of safety rods and control rods and temperature reactivity coefficients are calculated by MCNP-4C, WIMS and CITATION codes. If all the results meet safety criteria, the operation of the new core is permitted.

2. Reactor Description

The HWZPR core is cylindrical and has two control rods, two safety rods and 112 fuel rods, with a 20 cm square lattice pitch. In each fuel rod, there are 20 fuel slugs with height and diameter equal to 100 mm and 35 mm, respectively. The fuel tubes and clad of fuel slugs are made of aluminum alloy. The core of the reactor is surrounded by annular graphite reflector which is 75 cm thick. The heavy water is kept under low pressure nitrogen gas to avoid heavy water degradation. The height and diameter of the active core are 205 cm and 238 cm, respectively [1].

* zahranasr50@yahoo.com