3. Lead's chemical inertness is one of its most essential features as a coolant. In comparison to sodium and water, lead is a safe coolant since it does not promote rapid chemical reactions that could result in energy release in an accident.

REFERENCES

1. Britannica. Breeder reactor // URL: https://www.britannica.com/technology/breeder-reactor (date 06.04.2022)
2. IAEA. BREST-OD-300 // URL: https://aris.iaea.org/PDF/BREST-OD-300.pdf (date 06.04.2022)
3. JSC "Saint Petersburg Research and Design Institute "ATOMENERGOPROEKT". NPP with BN-800. 2011. 20 p
4. GENIVIV. Lead-Cooled Fast Reactor// URL: https://www.gen4.org/gif/jcms/c_42149/lead-cooled-fast-reactor-lfr (date 06.04.2022)

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MECHANICAL SPECTRAL SHIFT CONTROL FOR VVER-1000 REACTOR

Introduction

The mechanical spectral shift control (SSC) method has the potential for enhancing the utilization of nuclear fuel along with increasing the fuel cycle in nuclear reactors. The mechanical SSC approach is carried out by variation of the water-to-fuel volume ratio (VM/VF) through inserting displacer rods at the beginning of the cycle (BOC) into water tubes distributed uniformly within the fuel assembly and then withdrawing the displacer rods at the end of the cycle (EOC). In the present analysis, the mechanical SSC design of the VVER-1000 reactor with low enriched uranium (LEU) fuel assembly is applied. The obtained numerical values were compared with the benchmark exercise in which conventional control methods have been applied (600 ppm H_3BO_3 and 4.0 wt.% Gd_2O_3). The results demonstrated that the fuel discharge burnup has increased by 32% and the conversion ratio (CR) value reached up about 0.8 compared with the reference benchmark mean (BM) values.

The mechanical spectral shift control design concept

The mechanical spectral shift control (SSC) design represents an efficient alternative method for reactivity control in nuclear power plants in which reactor reactivity at the BOC is regulated in such a way that the fast fission neutron spectrum is shifted to epithermal neutron energy range [1]. As a consequence, the excess neutrons could be captured, mainly, in fertile fuel isotopes (U^{238}) rather than in conventional absorbing materials. As nuclear fuel depletion proceeds, the neutron spectrum is shifted from epithermal to the thermal range for recovering the core criticality conditions and burning the fissile isotopes (Pu^{239}, Pu^{241}) which bred at the beginning of the cycle. As a result, the SSC method is considered a promising solution for increasing fuel utilization along with improving fuel discharge burnup in nuclear reactors. The most recent study adopted for the SSC method which applied for VVER-1000 LEU assembly demonstrated an improvement in fuel discharge burnup by 60% and enhancing in the CR value to about 0.83 besides suppressing the Infinite Multiplication Factor value at the beginning of the cycle by -8% in comparison with traditional poison methods [2].

Description of the mechanical SSC model

The proposed mechanical SSC method in the present study has been applied to TVS-2M fuel assembly which is used in typical Russian designs of the VVER-1000 reactor. the variation of the water-to-fuel volume ratio (VM/VF) from a value of 1 at the BOC up to 2.13 at the EOC. In order to achieve this variation, mechanical modifications have been applied to the fuel assembly configuration. Firstly, 133 displacer rods have been incorporated with outer diameter equals 8.86 mm distributed in 19 group positions in uniform pattern with respect to fuel assembly cross section and every group position consists of 7 displacer rods as shown in Figure 1. The displacer rods which have been applied in the present model, made from natural uranium (NU-displacer rods), in which displacers can act as neutron absorbers and also produce more fissile plutonium. There are two different withdrawal strategies of NU-displacer rods adopted in the present analysis. The first case considered the full withdrawal approach of NU-displacer rods at burnup step 10 MWd/KgHM which is represented by the green line in Figures 2 and 3. Whereas in the second case as represented by the dashed red line in Figures 2 and 3, the partial withdrawal approach is applied in which the NU-displacer rods are removed from fuel assembly at different burnup steps, i.e., 10 and 23 MWd/KgHM.

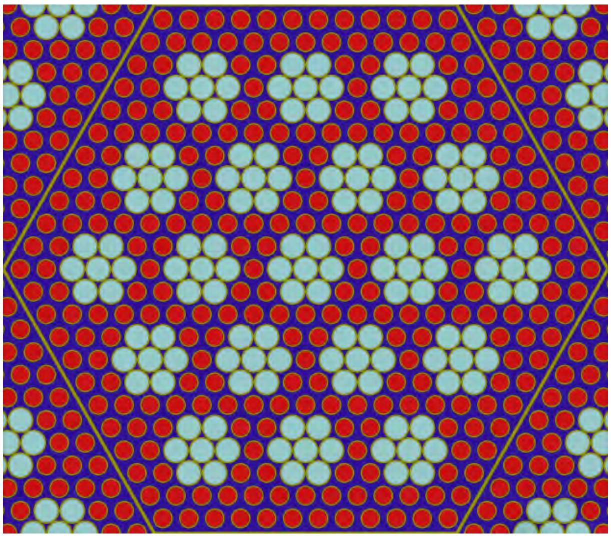

Fig. 1. Modified TVS-2M fuel assembly for mechanical SSC method.

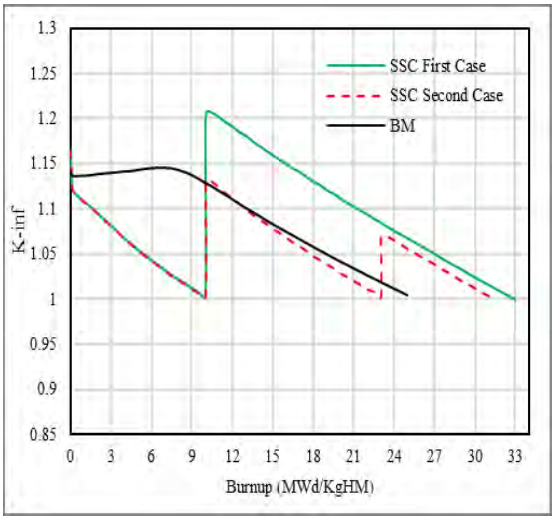

Fig. 2. Infinite Multiplication Factor variation during fuel burnup.

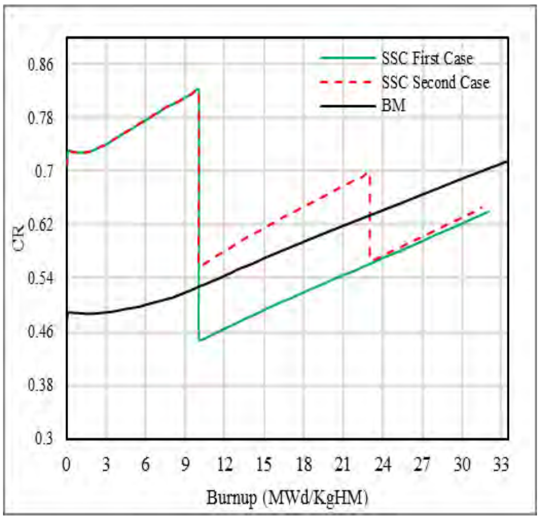

Fig. 3. Assembly Conversion Ratio variation during fuel burnup.

Results and discussion

The variation of infinite multiplication factor (k-inf) is presented in Figure 1 for both cases of withdrawal strategies of NU-displacer rods relative to benchmark reference case [3[during one batch fuel cycle scheme. It can be seen from Figure1, that fuel discharge burnup for both cases of the mechanical SSC method reached up the limit value of about 33 MWd/KgHM compared to 25 MWd/KgHM in the benchmark model case with an improvement in fuel burnup by 32 %. The comparison of CR values is presented in Figure 3 for both cases of withdrawal strategies of NU-displacer rods compared to the benchmark model during fuel burnup. As illustrated in Figure 3, the CR value for both cases of the mechanical SSC method initiated at about 0.8 higher than that has been getting in the first case (0.78). However, the CR values for both cases of withdrawal strategies of NU-displacer rods converged to the same value at about 0.64 toward the EOC. From the previous highlights, the mechanical SSC method has the potential for improving reactor conversion ratio and enhancing discharge burnup during one batch fuel cycle scheme.

REFERENCES

1. Sayles, C.W., "Shim control of heavy-water moderated power reactors by removal of light-water poison". Retrospective Theses and Dissertations. 3007(1964). 7 p.
2. Elzayat, T. et al., "Chemical spectral shift control method for VVER-1000 LEU fuel assembly benchmark." Annals of Nuclear Energy 165 (2022). 11 p.
3. Kalugin, M. et al., "A VVER-1000 LEU and MOX Assembly Computational Benchmark". NEA/NSC/DOC10 (2002). 30 p.

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THE HISTORY ABOUT THE DISCOVERY OF RADIATION AND ITS IMPACT ON THE ENVIRONMENT AS A SUBJECT OF TECHNICAL SCIENCE

Abstract
The article examines the contribution of scientists to the development of nuclear physics. The scientific portals of outstanding physicists who have made a great contribution to the development of nuclear physics are presented. Such as Marie Curie, J. Thomson. The author examines what dangers await humanity during a nuclear catastrophe. The article substantiates the need to study the history of nuclear physics for a successful career of a modern engineer.

Wilhelm Roentgen was the first to discover radiation. He discovered it in the form of x-rays in 1985, using J. J. Thomson’s cathode ray tube (CRT) technology. The first medical x-ray image he took was of the hand of his wife, Anna Bertha Ludwig. Henri Becquerel decided to work further on Wilhelm Roentgen’s discoveries by experimenting with phosphorescent substances. He spread uranium salt on black paper with a photographic plate wrapped in it and