KnE Engineering

AtomFuture-2017
XIII International Youth Scientific and Practical Conference
“FUTURE OF ATOMIC ENERGY - AtomFuture 2017”
Volume 2017

Conference Paper

Testing of the SERPENT 2 Software Package and Calculation of the VVR-ts Research Reactor Lifetime

Karazhelevskaya Yu. E.[1], **Kolesov V. V.**[1], **Kochnov O. Yu.**[2], **and Terekhova A. M.**[1]

[1]Obninsk Institute for Nuclear Power Engineering of the National Research Nuclear University MEPhI, Studgorodok 1, Obninsk, Kaluga region, 249040, Russia
[2]Branch of FSUE, Karpov Institute of Physical Chemistry (Kiyevskoye shosse 6, 249033 Obninsk, Kaluga reg. Russia)

Abstract

The possibility of calculating the non-standard geometry complex of the VVR-ts research reactor (a research water-water reactor for specific purposes) on the Serpent 2 software package is considered. Calculations of a real reactor lifetime conducted using the Serpent 2 software package are compared with calculations for the MCNP/VisualBurnOut and with the data from the archive.

Corresponding Author:
Karazhelevskaya Yu. E.
karazhielievskaia@mail.ru

Received: 23 December 2017
Accepted: 15 January 2018
Published: 21 February 2018

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the AtomFuture Conference Committee.

1. INTRODUCTION

The research nuclear reactor VVR-ts is located in the FSUE, Karpov Institute of Physical Chemistry (Obninsk) was put into operation in 1964. It was created to carry out a wide range of investigations in the area of radiation chemistry, radiation material science, activation analysis and many others [1].

At present, there is a need for modernization of the reactor core and targets to increase the ^{99}Mo production, the need for which is growing both in Russia and around the world [2]. Many computational studies have been carried out, the results of which will be used to modernize the core [5-9].

Since 2016, the PSG-2 / SERPENT software package [PC] PSG-2 / SERPENT [3], created by the VTT Technical Research Team of Finland (VTT Technical Research Center of Finland), which is designed to calculate neutron-physical characteristics of systems containing nuclear fissile materials have been launched at the IATE NRNU (MEPhI). The code uses the Monte Carlo method and also makes it possible to calculate the campaign for complex nuclear installations, such as the VVR-ts reactor. The paper attempts to use the code for two actual reactor campaigns calculation (23.03.2014 and 29.03.2014) and comparing the results with the data from the archive reactor lifetime.

How to cite this article: Karazhelevskaya Yu. E., Kolesov V. V., Kochnov O. Yu., and Terekhova A. M., (2017), “Testing of the SERPENT 2 Software Package and Calculation of the VVR-ts Research Reactor Lifetime” in *XIII International Youth Scientific and Practical Conference “FUTURE OF ATOMIC ENERGY - AtomFuture 2017”*, KnE Engineering, pages 355–360. DOI 10.18502/keg.v3i3.1635

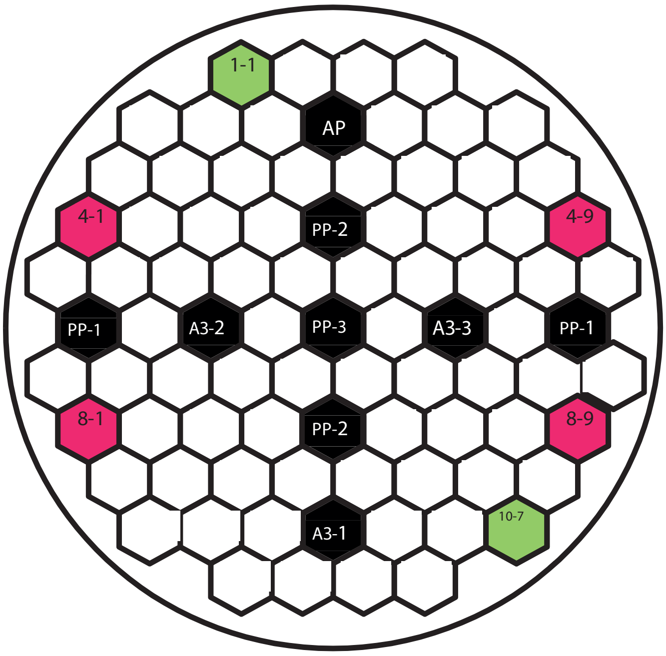

Figure 1: The reactor core cartogram of the standard VVR-ts core.

2. MATERIALS AND METHODS

The core of the VVR-ts research reactor consists of 70 fuel assemblies and 9 control rods and protection system (CPS) regulators (Figure 1). Each fuel assembly consists of 5 plate-type fuel pins (Figure 2). Four fuel pins have hexagonal cross-section, the fifth, internal fuel pin, has a circular cross-section [10]. Channels of CPS rods and experimental channels along the height of the core also have a hexagonal cross-section and are distanced from the fuel assembly. The circulation of cooling water through the core goes from the top down (presses the fuel assembly to the grate) [1].

At the beginning of the campaign, the position of the rods was determined so that the state of the reactor was close to critical. All emergency protection rods and control rod-1 are in the valve-up position. The control rod-3 is completely immersed in the core, and control rod-2 is immersed in the core by 40 cm, and the automatic regulator by 20 cm (Figure 3).

3. DISCUSSIONS

When calculating the model of the VVR-ts reactor, the following problems arose:

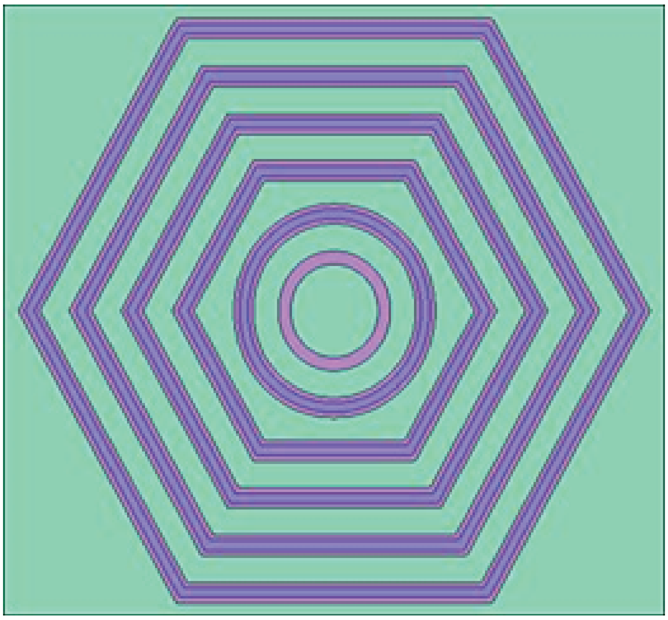

Figure 2: The VVR-ts assembly.

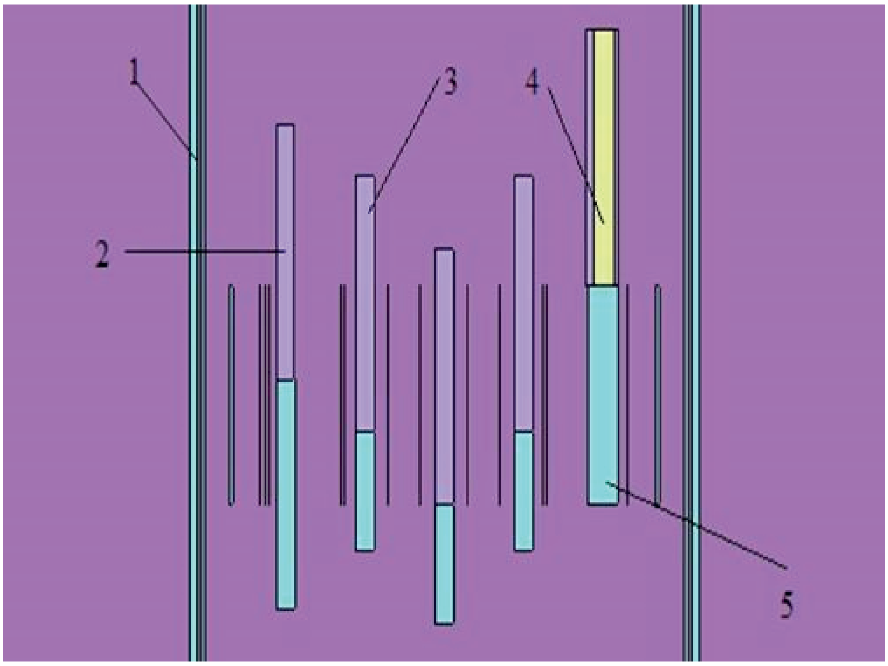

Figure 3: The position of the CPS rods in the core of the VVR-ts reactor: 1. Reactor tank, 2. Automatic control rod, 3. Manual control rod, 4. Automatic protection rod, 5. Displacer.

1. The specified non-standard geometry turned out to be too complicated and the Serpent code could not calculate assemblies volumes, so all volumes had to be manually set.

2. The burned-off fuel assemblies with a large number of fission fragments are used in the VVR-ts reactor, therefore, a large amount of memory is needed for the calculation.

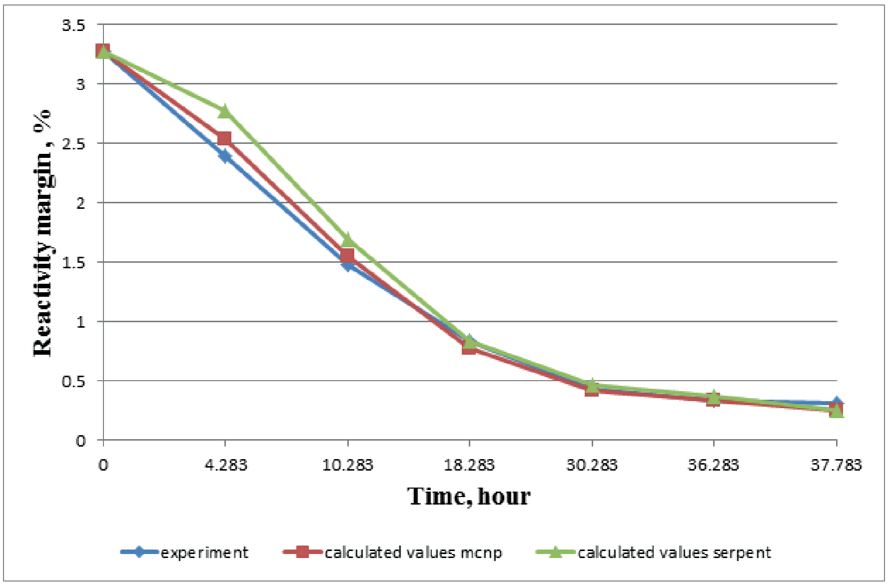

Figure 4: Change in the reactivity margin in time for the first campaign.

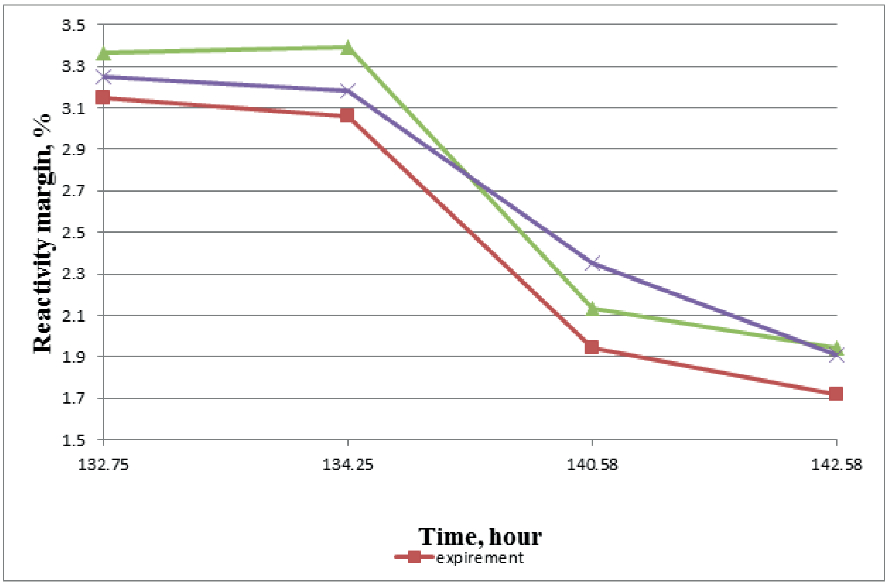

Figure 5: Change in the reactivity margin in time for the second campaign.

In order to solve the second problem, all calculations were performed on the cluster of the IATE NRNU (MEPhI), which has 7 nodes (memory from 4 to 16 GB depending on the node), an eight-core Intel Xeon processor. The standard evaluated nuclear data library ENDF / B-VII, supplied with the Serpent 2 code, was used as a constant supply. Two successive VVR-ts reactor campaigns were calculated. At the same time, the second campaign began on a reactor that remained poisoned xenon.

The reactivity margins obtained during the campaigns (Figures 4, 5) were compared with the results obtained using the MCNP/BurnBurnOut [4] and with the data from the archives of the FSUE, Karpov Institute of Physical Chemistry.

4. CONCLUSIONS

The results show the principal possibility of using the Serpent 2 code for calculating the VVR-ts reactor campaigns. In this case, there is a marked difference in the values of the reactivity margins obtained in this work from the data from the archive at the beginning of the first campaign. The difference disappears at the end of the campaign. The values of the reactivity margins calculated in Serpent 2 in the second campaign are greater than the values obtained from the archive.

In the future it is planned to use the Serpent 2 code to conduct research on the modernization of targets for radionuclide production in the core of the VVR-c reactor.

References

[1] Kochnov O.Yu., Lukin N.D. VVR-ts - stages of reactor reconstruction. Abstracts of the report for the XI Russian Conference ”Safety of Research Nuclear Reactors”, Dimitrovgrad, May 25-30, Year: 2015, Page: 35-36.

[2] Kolesov VV, Kochnov O.Yu., Volkov Yu.V., Ukraintsev V.F., Fomin.R.V., Creation of a precision model of the VVR-ts reactor for the subsequent optimization of its design and the development of radionuclides. In the collection: ”Safety of Nuclear Power Plants and Training of Personnel-2011”, Obninsk, Year: 2011, Volume: 2, Page: 144-146.

[3] Jaakko Leppänen, PSG2 / Serpent2 – a Continuous-energy Monte Carlo Reactor Physics Burnup Calculation Code. Methodology – User's Manual – Validation Report:, 2012.

[4] Kolesov VV, Kamayev DA, Ukraintsev VF, Khitrik D.V., Using the method of interval calculations to obtain estimates of the errors in fuel characteristics during the campaign // Nuclear Power Engineering, Izv. Institutions of Higher Education, Year: 2007, Volume: 2, Page: 3-7.

[5] Kochnov O.Yu., Kolesov VV, Fomin R.V. Estimation of energy release in a target with a uranium-containing material in the production of 99Mo using targets of an improved design at the VVR-c reactor// Nuclear Power Engineering, Izv. Universities, Year: 2012, Volume: 4, Page: 23-28.

[6] Kochnov O.Yu., Kolesov VV, Fomin R.V., An estimate of the increase in production of 99Mo for various arrangements of the core at the VVR-c reactor // Nuclear Power Engineering, Izv. Universities, Year: 2013, Volume: 1, Page: 110-115.

[7] Kochnov O. Yu., Kolesov V. V., Fomin R. V., Improvement of the Neutron-Physical Characteristics of the VVR-Ts Reactor by Substituting a Beryllium Reflector for Some Fuel Assemblies in the Core // Atomic Energy, Year: 2015, Volume: 118, Issue: 4, Page: 238-241. DOI: 10.1007/s10512-015-9986-5

[8] Kochnov O.Yu., Kolesov V.V., Fomin R.V., Zherdev G.M., An estimate of the increase in production of 131I using tellurium targets of an improved design at the VVR-c reactor// Nuclear Power Engineering, Izv. Universities, Year: 2014, Volume: 4, Page: 102-110.

[9] Kochnov O. Yu., Kolesov V. V., Fomin R. V., Modernization of the VVR-TS reactor core for the increasing of the radionuclides production // Journal of Physics: Conference Series, Year: 2017, Volume: 781, Issue: 1. DOI: 10.1088/1742-6596/781/1/012031

[10] Karazhelevskaya Yu.E., Kolesov V.V., Modeling of the core of the research reactor VVR-ts on the software complex ”Serpent”. In the collection of abstracts: ”Nuclear Power Plants of Ultra-Low Power for Applied and Educational Purposes”, Obninsk, Year: 2016, Page: 22-24.