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Benchmark-experiment for evaluating nuclear data libraries used to model subcritical blanks of thermonuclear installations

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ABSTRACT

A description of a micro-model of a salt blanket for conducting benchmark experiments with the melting of salt fluorides (NaF (52.2% mas.) + ZrF_4 (47.8% mas.)) is given. The experiments are intended for verification of nuclear data libraries and codes applied to justify the nuclear and radiation safety of full-scale subcritical blankets of fusion devices based on liquid-salt technologies. Three dry experimental ducts are in the salt blanket micromodel. Pencil cases with experimental samples (natNi, natZr, natCd, natTi, ^{59}Co, ^{63}Cu, ^{65}Cu, ^{64}Zn, natIn, ^{27}Al, natMg, natFe, ^{169}Tm, ^{197}Au, ^{232}Th) are placed in the ducts. A neutron generator NG24M with a neutron yield of ~ 10^{11} n /s is used as a source of neutrons with an energy of 14 MeV.

BACKGROUND

Fusion neutron source (FNS) is a fusion device on the periphery of which subcritical blankets is placed. A neutron spectrum of FNS obtains a high-energy "tail" with the energy of ~ 14 MeV appears, which is not typical for conventional nuclear reactor systems. This requires benchmark experiments to verify the used codes and nuclear data libraries.

Currently, there are no benchmark experiments with various models of blankets that can be used for the verification matrix of codes used to justify the nuclear and radiation safety of full-scale subcritical blankets.

The task of this project is to provide benchmark experiments with the salt blanket micromodel for the definition of integral data and to discuss the results of their modeling performed using various cross-section libraries.

At the first stage of the work, the conditions for simulating uniform irradiation of a blanket in the field of a neutron generator are investigated and the corresponding improvement of the computational model is carried out.

METHOD AND CALCULATION MODEL

A Monte-Carlo computer simulation was carried out for the calculations of the salt blanket micromodels. The MCNP-4 code [14] was used with cross-sections from the files FENDL-3 and ENDF/B-VII.

Following the technical documentation for the production of a blank for conducting benchmark experiments, a calculated micromodel of a liquid-salt blank was created. The salt blanket with a width of 522 mm, a length of 522 mm, and a height of 522 mm is filled with NaF (52.2% mas.) + ZrF_4 (47.8% mas.) salt fluoride melt and surrounded by a tank with a water moderator, which allows regulating the neutron spectrum. The neutron generator NG-24 with a neutron output of ~ $1.5 \cdot 10^{11}$ is used as a neutron source.

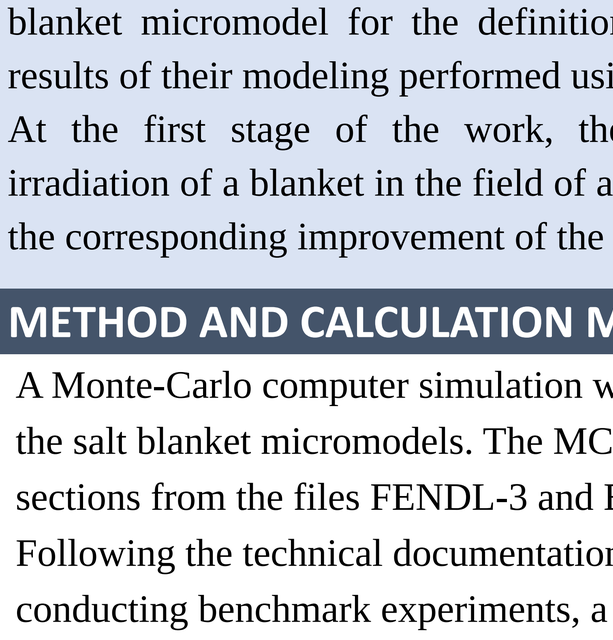

FIG. 1. Vertical section of a three-dimensional micromodel with the x-z plane.

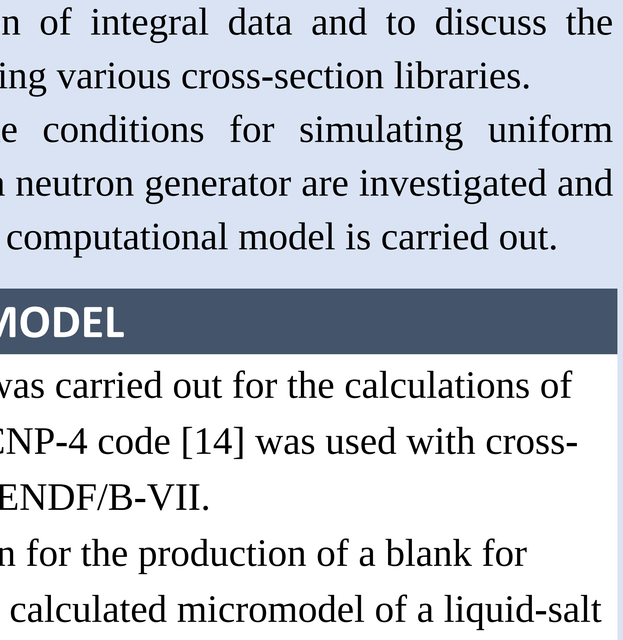

FIG. 2. Vertical section of a three-dimensional micromodel with the y-z plane.

OUTCOME

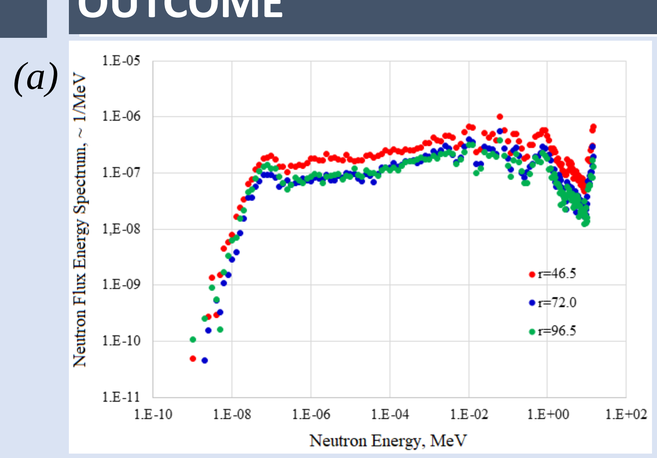

FIG. 3. Neutron flux energy spectrum (a) and the reaction rate (n, p) and (n, 2n) (b) in the blanket ducts located at a distance of r mm from the central axis of the blanket, when the duct with r=46.5 mm is in front of a 14 MeV neutron source with a power of 1 n/s.

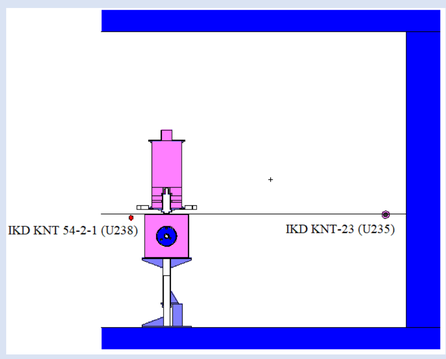

FIG. 4. Position of IKD KNT 54-2-1 (U238) and IKD KNT-23 (U235) detector in the experiment room.

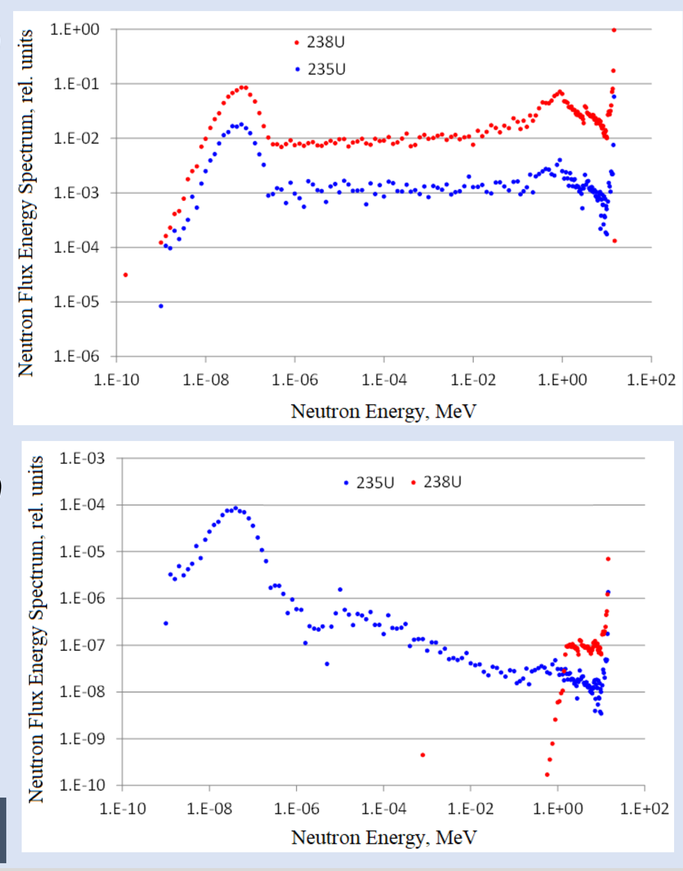

FIG.5. Neutron spectrum (a) and the fission reaction rate (b) at the test point of IKD KNT 54-2-1 (238U) and IKD KNT-23 (235U).

CONCLUSION

At the first stage of the project, an experimental device with a micromodel of a salt fusion blanket was created. The salt blanket with dimensions of 522X522X522 mm is filled with NaF (52.2% mas.) + ZrF_4 (47.8% mas.) salt fluoride melt and surrounded by a tank with a water moderator, which allows regulating the neutron spectrum. The neutron generator NG-24 with a neutron output of ~ $1.5 \cdot 10^{11}$ is used as a neutron source.

The work plan for this stage has been completed. The necessary technical documentation has been developed and the following device elements have been manufactured: tank for moderator, filling-draining water system, the device for fastening salt blanket micromodel, and device of its rotation. Assembling the device was performed. Experimental samples were made from metal foils of different chemical compositions. The possibility of transporting the samples is provided.

The gamma-ray spectrometers were calibrated using gamma sources from the OSGI set. The three three-dimensional mathematical models have been developed:

a) the laboratory room together with NG24;

b) the laboratory room together with NG24 and the micromodel of the salt blanket without water in the tank;

c) the laboratory room together with NG24 and the micromodel of the salt blanket with water in the tank.

A calculated estimation of the perturbation of fast neutron flux monitoring caused by the placement of a salt blanket micromodel was performed.

The result of the first stage is the assembled device and the first test calculations. The experimental research has just been started.

ACKNOWLEDGEMENTS / REFERENCES

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