Review

of the project “Construction of a complex of combined neutron moderators at the IBR-2 reactor” submitted for consideration to the PAC for Condensed Matter Physics

The aim of the project under consideration is the construction of a complex of neutron moderators at the modernized IBR-2 reactor, making it possible to vary the spectral distribution of the neutron flux delivered to the reactor’s spectrometers, covering an energy range from thermal to cold neutrons.

In the process of development and construction of neutron moderators, consideration was given to geometric parameters of the core, technological equipment and physics research instruments. Each moderator has water chambers forming a thermal neutron flux and a cryogenic chamber to moderate neutrons down to cold energies. At the same time, the arrangement of these chambers in the head part of each moderator is different and depends on the required parameters of the experimental instruments for which the moderator was constructed. The application of an individual approach to the construction of moderators made it possible to provide the optimal neutron spectrum for the instruments of various types, which significantly improves the efficiency of these setups and enhances their capabilities for solving scientific problems.

The operation of the complex of cryogenic moderators is based on the unique scientific and technical solutions which were implemented for the first time in the course of its development. The main part of the moderator is a chamber filled with solid beads of a mixture of mesitylene and m-xylene in the ratio of 3:1. This mixture exhibits one of the highest levels of radiation resistance among hydrogen-containing compounds. Earlier, the optimal geometry of the moderator, method of producing beads, their pneumatic delivery to the chamber and subsequent removal after work cycles have been theoretically grounded and experimentally tested with a full-scale prototype.

The first combined cryogenic moderator CM-202 for IBR-2 beamlines 7, 8, 10 and 11 was successfully launched in 2012. In the process of its operation, the period of continuous operation of this moderator was extended up to 11.3 days, the radiation dose for the working substance was 160 MGy, and the decrease in the cold neutron flux did not exceed 10-15%. On the whole, these parameters meet the requirements for the optimal use of IBR-2 experimental facilities for physics experiments.

In 2017-2019, in the framework of the project, a new refrigerator with a cooling power of 1200 W at 10 K was purchased and put into operation. Upon its commissioning, the cryogenic part of the complex cooling system underwent a significant modernization. The new solutions made it possible to reduce the total heat gain, expand the range of operating temperatures and provide an individual temperature regime in each of the moderators. It became possible to change the temperature of the working substance in a wide range from 20 K to 150 K, thus shifting the neutron flux spectrum peak to longer or shorter wavelengths, according to experimenters’ needs. A decrease in the total heat gain resulted in a decrease in temperature in the moderator chamber from 32 K to 22 K, while the flux of neutrons with a wavelength of 7 Å increased by 22%. The gain in the cold neutron flux was a factor of up to 16.

At present, JINR is a pioneer in the use of a pelletized cryogenic neutron moderator. The intellectual property for the technical solutions developed in the course of its development and

construction has been protected by several patents. In terms of the cold neutron flux density on the moderator surface, the cryogenic moderator CM-202 at the IBR-2 reactor compares well with those at the world's most intense pulsed neutron source SNS (Oak-Ridge, USA), and in terms of the neutron flux per pulse it exceeds them by a factor of six (due to lower pulse repetition rate).

In view of the positive experience of CM-202 operation, in the framework of the project in 2017-2019, work was carried out to develop and construct a CM-201 moderator for beamlines 1, 4, 5, 6, 9. The expected gain in the long-wavelength neutron flux is a factor of up to 9, and for thermal neutrons in the direction of beamline 1 is a factor of up to 1.4. The moderator has already been manufactured and undergone preliminary on-site fitting and testing procedures. Its commissioning into trial operation is scheduled for the autumn of 2019.

In the upcoming period of 2020-2022, the planned activities under the project will involve a number of experiments aimed at studying the neutron-physical parameters of the new CM-201 moderator, optimizing its operating modes, determining the thermophysical properties of the cooling system in view of the commissioning of new equipment. In the framework of the project, it is planned to install and put into operation a new refrigerator from Linde AG with a cooling power of 1800 W at 10 K, partially automatize the dehydrogenation process and the vacuum system. Further modernization of the cryogenic system will provide an additional gain in the cold neutron flux, as well as ensure trouble-free operation of the entire complex of cryogenic moderators in the long term.

In view of the successful implementation of the project on the construction of a complex of combined cryogenic moderators, as well as high qualification of the project team, the feasibility of planned activities under the project is beyond any doubt.

The commissioning of the entire complex of combined cryogenic moderators will significantly expand the range of research topics at IBR-2 and increase the efficiency of investigations in most promising scientific fields. This will strengthen the JINR position among the leading research centers in the field of neutron investigations of condensed matter.

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