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4. MBIR – an innovative reactor for support of innovative designs

The prospects of nuclear power depend on development of fast neutron reactors with a closed fuel cycle. With this recognized, the Federal Target Program "Nuclear Power Technologies of a New Generation in the Period to 2015 and in a Longer Term to 2020" provides for building a multipurpose fast research reactor MBIR.

The MBIR reactor is to be built and commissioned by 2020 on the site of OJSC "SSC NIIAR" in Dimitrovgrad, Ulyanovsk Region.

The principal idea is to ensure not only continuity in implementation of the experimental and research programs that are in progress at BOR-60 but also innovative development of the nuclear experimental capabilities. Besides, MBIR is expected to become a modern tool at the disposal of the prospective international multiuser center for experimental studies to support innovative fast reactor technologies.

At present, MBIR designers are being guided by the initial concept of the project to attain the final goal of commissioning this reactor by the specified term. The concept has the following key points:

– MBIR should be designed with the priority given to research tasks and with due regard for the reliability and safety of its operation;

– MBIR should be built on the site of an organization which has continuous experience of many years in operating a similar research reactor, the required infrastructure and personnel for the reactor operation, preparation and conduct of experimental activities, and for processing of the resulting information;

– the reactor should be built quickly enough;

– the key engineering and technological principles designed into MBIR should be tried out and confirmed by practical experience;

– the reactor fuel costs should be minimized;

– MBIR development should ensure in-core neutron flux of no less than $5.5 \cdot 10^{15}$ $cm^{-2} \cdot s^{-1}$ at the minimum thermal power level essential for its attainment;

– the experimental capabilities of MBIR should meet as fully as possible the current and longer-term tasks of the programs for development of innovative reactor facility designs;

– the configuration of the MBIR facility should provide for installation of independent loops with various types of coolants;

– the new research reactor should comply with the requirements of the current Russian safety regulations;

– international collaboration should be promoted, beginning with the stage of the MBIR research program development.

The following MBIR applications have been adopted for the research program elaboration:

– radiation tests of advanced structural materials under conditions of intensive neutron radiation with the flux up to $(5\ldots6) \cdot 10^{15}$ $cm^{-2} \cdot s^{-1}$;

– study of advanced nuclear fuels and absorber materials for both fast and thermal reactors;

– in-pile tests and trials of operation modes of fuel elements, fuel assemblies, absorber elements, and other core components for innovative reactors of the next generation with sodium, heavy metal, gas and molten salt coolants;

– study of fuel behavior during transients, in cyclic and emergency operation conditions;

– study of new and modified liquid metal coolants, of the engineered features for their monitoring and quality control;

– material tests, neutronic, thermal-hydraulic and other studies for verification of computer codes;

– tests and approval of new types of components for various process systems, of innovative instruments, reactor monitoring, control and diagnostic systems, etc.;

– in-pile tests and studies to address the problems of closed fuel cycle, burning of actinides and transmutation of long-lived fission products;

– production of various radioisotopes and modified materials;

– applied research with the use of neutron beams (neutronography and tomography of various materials and products);

– use of neutron beams for medical purposes.

In addition, the reactor is proposed to be used for power generation.

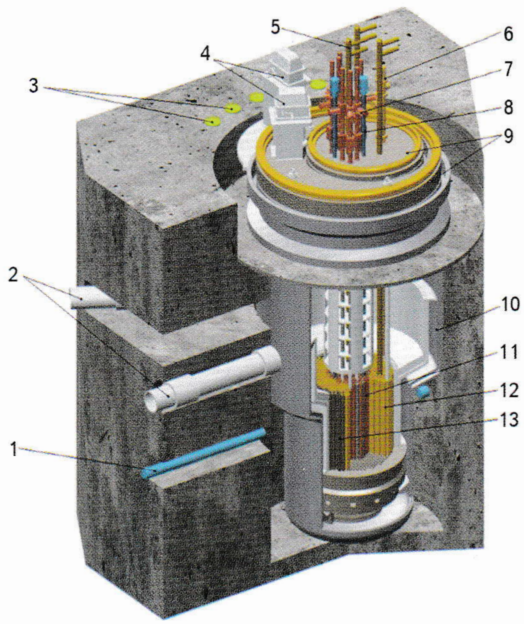
Main parameters and characteristics of the reactor

MBIR is a nuclear research facility with a multipurpose 150 MWt fast neutron reactor cooled by liquid metal, with in- and out-of-vessel experimental facilities and devices, designed for a wide spectrum of research activities.

In 2010, OJSC "NIKIET" (Chief Designer), FSUE "SSC RF-FEI" (Scientific Leader), OJSC "Leading Institute VNIPIET" (Architect Engineer), and OJSC "SSC NIIAR" (Operator) – joined forces to work out a technical assignment for design of the reactor facility with the following main parameters:

Thermal power	Up to 150 MW
Coolant	Liquid sodium
Fuel	Mixed U-Pu oxides
Neutron flux, max.	Up to $5.5 \cdot 10^{15}$ $cm^{-2} \cdot s^{-1}$
Experimental devices	
Large loop channel in the core	1
Large loop channels in the reflector	Up to 2
In-vessel self-contained channels in the core	Up to 3
Cells for instrumented channels in the core	Up to 3
Cells for isotope assemblies in the core	Up to 6
Cells for material test assemblies in the reflector	Up to 40...50 (limited by the reflector volume)
Cells for isotope assemblies in the reflector	Up to 40...50 (limited by the reflector volume)
Inclined experimental channels outside the vessel	Up to 12
Horizontal experimental channels	Up to 5

A general view of MBIR in a 3-D geometry is presented in the Figure below.



3-D MBIR model:
1 – horizontal experimental channel; 2 – primary pipelines; 3 – vertical experimental channels; 4 – rotary plug drives; 5 – large loop channel; 6 – reloading mechanism; 7 – CPS rod drives; 8 – experimental channel; 9 – rotary plugs; 10 – vessel with a safeguard shroud; 11 – fuel assembly; 12 – side reflector; 13 – in-reactor storage

The MBIR vessel is designed to house the following experimental equipment:

– large loop channels for simulating the operating conditions of reactor cores with various coo-lants;

– self-contained channels with circulation of various coolants inside them;

– instrumented assemblies for testing fuel, absorber and structural materials;

– non-instrumented material test assemblies;

– non-instrumented assemblies for isotope production.

A self-contained channel provides and maintains the preset thermodynamic parameters of fuel cooling by natural or forced coolant circulation set up inside this channel, with the instrumentation cables and service lines terminating outside the reactor.

The instrumented assemblies have up to 50 service lines (measurement and/or power lines, gas lines of specimen loading systems, etc.).

The MBIR building is designed to have five compartments for equipment of loop facilities with coolant of five different types (sodium, lead, lead-bismuth, gas, molten salts); each of them can be connected to one of the large loop channels. Tables 1 and 2 present the characteristics of experimental sections in the reactor.

MBIR offers wider experimental possibilities in comparison with BOR-60 owing primarily to the existence of loop facilities with different coolants. The reactor will provide a proper setting for experimental studies of fuel behavior during simulated transients and off-normal conditions in the presence of various coolants.

In its development, the MBIR Project had the following milestones:

– official approval of the Program "Nuclear Power Technologies of a New Generation…" which provides for MBIR construction by 2020;

– approval of the Technical Assignment for the MBIR facility;

– declaration made by General Director of the State Corporation "Rosatom" at the General Session of the IAEA in September 2010 to the effect that Russia was prepared to let MBIR be used as a shared pivotal facility of the prospective international center.

Common information space of the project

Simultaneously with the design activities and issue of the associated documentation, efforts were undertaken to set up Common Information Space (CIS) of the MBIR Project. The CIS concept envisions involvement therein of all the major participants of this Project.

The MBIR CIS is an information system with four key operation areas for:

– electronic archive management;
– 3-D modeling;
– project management;
– video conferencing.

Table 1

Characteristics of in-vessel experimental sections

Experimental devices	Location	Number	Core-level dimension, mm	Neutron flux in a cell, $cm^{-2} \cdot s^{-1}$
Cells for non-instrumented material testing assemblies and isotope production assemblies	Core	Up to 14	Instead of one core cell. Width across flats – 72	Maximum: $4.9 \cdot 10^{15}$ Core-averaged: $3.6 \cdot 10^{15}$
Cells for non-instrumented material testing assemblies and isotope production assemblies	Side reflector	Not limited	Instead of one core cell. Width across flats – 72	
Experimental sections for instrumented irradiation devices and/or self-contained channels	Core	Up to 3	Instead of one core cell. Width across flats – 72	$(3.7…4) \cdot 10^{15}$
Positions for large loop channels	Core center	1	Instead of seven core cells Ø 100	$5.04 \cdot 10^{15}$
	Side reflector	Up to 2		$(1.1…1.6) \cdot 10^{15}$

Table 2

Experimental channels outside the vessel

Experimental devices	Diameter, mm	Number
Horizontal experimental channels (HEC)	200	3
Vertical experimental channels (VEC)	~350 ~50	Up to 7 2

All the above components are integrated into one system by means of software wrapper Windchill 10.0.

An electronic archive of MBIR data has been set up. It allows structuring information by its types (documents, drawings, 3-D and computation models, etc.). Access to the archive for outside organizations is provided via a protected communication link to rule out uses of the stored data by third parties.

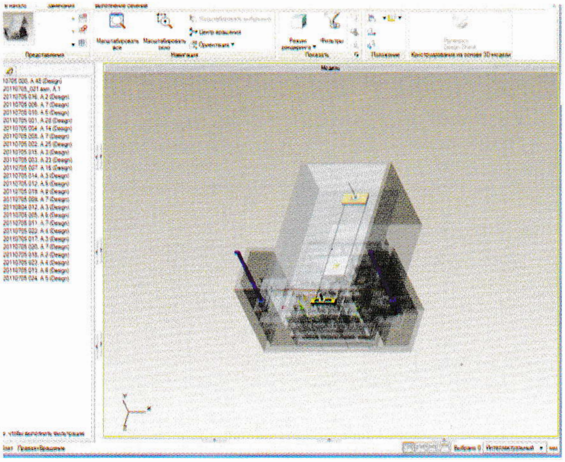
Current 3-D modeling of the reactor facility relies on another product of the PTC company, namely: Creo 1.0. This approach allows the fullest possible integration of the 3-D MBIR model into the CIS, which will make possible to joint on-line elaboration of the model by different organizations.

A Windchill-based system for electronic coordination of documents is planned to be introduced, which will speed up preparation of design documents.

For project management, Windchill offers the option of drawing up time schedules, roadmaps, etc. with their subsequent graphic presentation.

The video conferencing procedure, tried out already during the Moscow–Obninsk–Petersburg–Dimitrovgrad conference, will save time taken by coordination and important decision-making.

It is planned to start construction activities on the site in 2014 and to put the reactor into operation by 2020.



3-D MBIR model in the CIS archive

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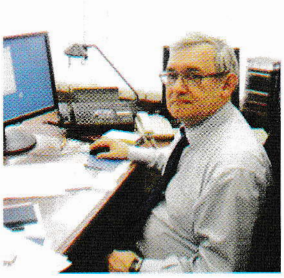

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