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PROSPECTS OF THE DEVELOPMENT OF THE SODIUM COOLED FAST REACTORS IN RUSSIA AND INTERNATIONAL COOPERATION

Y. Ashurko, V. Kagramanyan, E. Poplavskaya

State Scientific Center of the Russian Federation –
Institute for Physics and Power Engineering (SSC RF-IPPE), Obninsk

Bases for SFR development in Russia

- Favorable prospects of the further SFR development in Russia are determined by the following objective and subjective factors:
  - *Considerable and successful SFR operational experience that testifies to industrial level of mastering this reactor technology is gained;*
  - *Strategic policy of the State Atomic Energy Corporation "Rosatom" is aimed at creation of a new technological platform (NTP) for the future nuclear power and SFR have been selected as one of the reactor technologies basing the NTP;*
  - *SFR have the unique potential features permitting to create on their basis the stable, safe and economically profitable large-scale nuclear power that meets increasing energy needs of mankind.*

Operational SFR experience gained in Russia (1/2)

Accumulated operational experience – more than 143 reactor-years

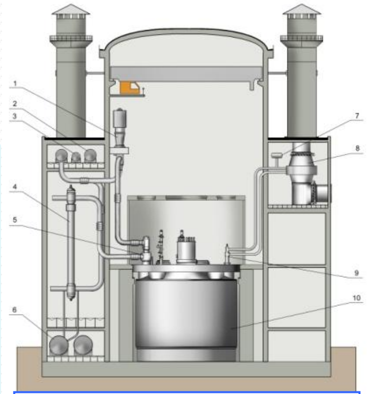
BR-5/10
1959-2002, Obninsk
(43.9 r-y)

BOR-60
1969, Dimitrovgrad
(41.5 r-y)

BN-350
1972-1999, Aktau
(26.4 r-y)

BN-600
1980, Zarechny
(31.3 r-y)

BN-800
2014, Zarechny



BN-1200

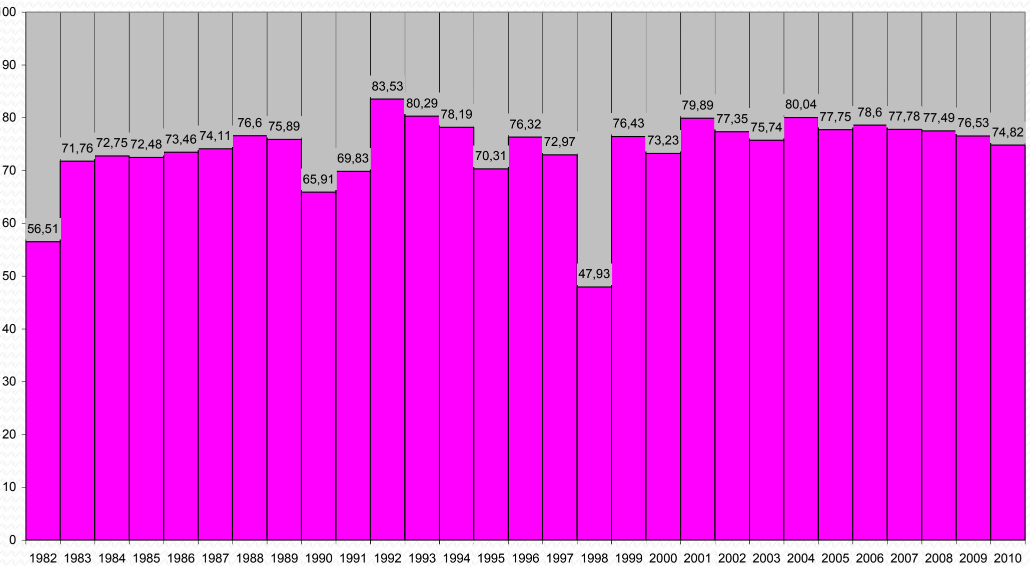
Thus, Russian operational experience on SFR makes more than 35% of the worldwide SFR operational experience that is equal to ~405 reactor-years.

Successful operation of the BN-600 during design lifetime (30 years) and its lifetime extension for next 10 years till 2020 allows speaking about:

- ***Industrial mastering SFR technology on the whole and capability of their stable commercial operation;***
- ***Reliable mastering sodium coolant technology;***
- ***Low corrosion activity of sodium coolant and capability of achievement of long-term operation of large-size sodium equipment.***

Operational SFR experience gained in Russia (2/2)

Change of load factor during the BN-600 power unit commercial operation



Achieved parameters on operation time and lifetime of the SFR equipment without overhaul, h

Type of equipment	BR-5/BR-10	BOR-60	BN-350	BN-600
Non-replaceable equipment: Reactor vessel Primary pipings	 150 000 300 000	 225 000 225 000	 170 000 170 000	 205 000 205 000
Sodium pumps	170 000 electro-magnetic	260 000 mecha-nical	100 000 mecha-nical	105 000 mecha-nical
Intermediate heat exchangers	300 000	225 000	170 000	205 000
Steam generators	-	155 000 reverse SG	150 000	125 000 evapo-rators

The last outside sodium leak occurred at the BN-600 17 years ago – in May 1994.
As for leaks in SG, during recent 26 years of the BN-600 operation there was only one small leak in SG more than 20 years ago in January 1991.

Construction of the BN-800 power unit

Construction of the 4th power unit with the BN-800 reactor is carried on Beloyarsk NPP site.

Date of construction completion and power unit commissioning is scheduled in 2014.

The BN-800 is planned to be used for:

- **Closing nuclear fuel cycle;**
- **Recycling stocks of weapon-grade plutonium.**

Federal Target Program on NTP (1/3)

- *On 21.01.2010, the Government of the Russian Federation had approved the Federal Target Program (FTP) "Nuclear power technologies of a new generation for period of 2010-2015 and with outlook to 2020".*
- *This FTP is aimed at the development and construction of the NTP for nuclear power based on transition to the closed nuclear fuel cycle (CNFC) with fast reactors of the 4th generation.*
- *In order to implement the transition to the new technological platform the FTP envisages the activities in the following directions:*

Development of advanced reactor technologies of the fourth generation;

Construction of new test facilities and installations, upgrading and development of an experimental and bench-scale base in support and justification of the reactor technologies under development;

Development of the technologies for production of advanced types of fuel for reactors of the next generation;

Creation of materials and technologies of the CNFC for nuclear power systems with fast and thermal reactors of the new generation;

Development of the integrated code systems of a new generation for analyses and substantiation of safety of advanced NPPs and CNFC.

- *Funding for the FTP makes 110 billion roubles.*

Federal Target Program on NTP (2/3)

- The FTP frameworks envisage research in area of fast reactors and the respective fuel cycles:
  - *BN-1200 reactor design with sodium coolant;*
  - *BREST reactor design with lead coolant;*
  - *SVBR reactor design with lead-bismuth coolant.*
- The FTP implementation should be realized in two stages:

The first stage (2010-2014):

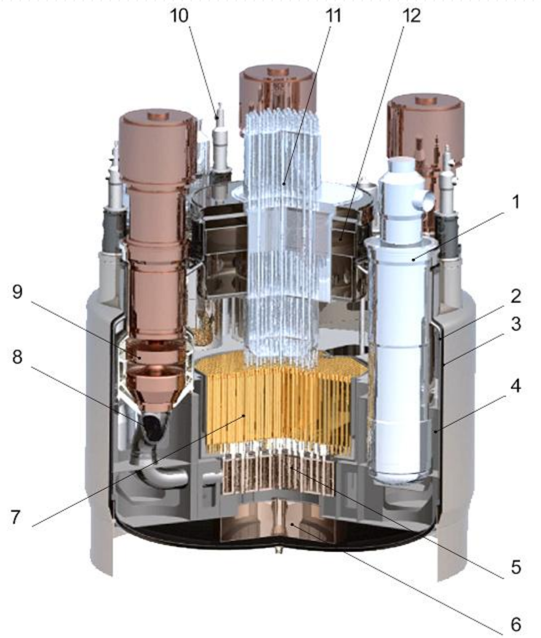
- *Development of basic designs of the above-listed fast reactors of the 4th generation;*
- *Completion of designing and commissioning of uranium-plutonium oxide fuel production plant for fast reactors of the new generation;*
- *Development of a detailed design for construction of a multipurpose research fast reactor (MBIR) with sodium coolant, aimed at conduction of reactor studies including testing of new types of fuel, various coolants, fuel and structural materials;*
- *Development of new radiation-resistant structural materials for the reactors of the new generation, providing operational capability of fuel pins up to 120-150 dpa.*

Federal Target Program on NTP (3/3)

The second stage (2015-2020):

- *Construction of demonstration and prototype facilities with the BREST and the SVBR reactors;*
- *Construction, refurbishment, technical upgrading and commissioning the required research base purposed for the justification of the new technological platform of nuclear power, including the MBIR reactor construction and commissioning the technically reequipped complex of big test facilities (BFS).*
- *Set-up of a pilot plant for production of compact fuel for nuclear reactors of the new generation;*
- *Construction of a demonstration semi-commercial pyrochemical complex for fuelling nuclear reactors of the fourth generation.*

Development of the BN-1200 design



- The development of the 4th generation SFR BN-1200 design is carried out in accordance with the FTP now.
- Development of the BN-1200 design is scheduled to be completed in 2014.
- A FOAK power unit with the BN-1200 reactor is scheduled to be constructed by 2020.
- The BelNPP site is considered as probable place of its location.
- Further it is envisaged to develop a serial SFR design on the basis of the BN-1200 design.
- The BN-1200 design provides:
  - *Traditional three-circuit design of the power unit with mastered parameters of the coolant and tertiary circuit;*
  - *Flexible nuclear fuel cycle allowing transition from fuel made on the basis of plutonium extracted from SNF of thermal reactors to fuel made on the basis of own plutonium and providing opportunity of using different types of fuel (oxide, nitride).*
- The following innovative technical and design decisions are proposed:
  - *Pool type arrangement of the primary circuit with location of all sodium systems including auxiliary ones within the reactor vessel;*
  - *Simplification of a refueling system by exception of intermediate storage drums of fresh and spent FSAs and organization of a capacious in-reactor vessel storage;*
  - *Transition from sectional-modular SG scheme to integral one;*
  - *Maximum enhancement of inherent safety features of the reactor facility and application of safety systems based on passive principles of functioning*:
    - ✓ Passive systems of emergency protection;
    - ✓ Passive decay heat removal system through independent loops connected to the reactor vessel.

Upgrading experimental base on SFR

- Upgrading and expansion of the SFR experimental base is considered as very important activities on creation of the NTP:
  - *Lifetime extension of the BOR-60 by the end of 2015;*
  - *Upgrading the BFS complex;*
  - *Development and construction of the MBIR research fast reactor;*
  - *Construction of new experimental facilities for tests of separate SFR systems and equipment, in particular SAZ facility for SG studies;*
  - *Application of the BR-10 for development of SFR decommissioning technologies etc.*
- Data acquisition for verification of computational codes is one of the important directions of use of the SFR experimental facilities.

Long-term prospects on SFR

- In long-term perspective SFR are considered as one of the 4th generation reactor technologies that owing to the unique characteristics can make a basis of future nuclear power thanks to:
  - *Effective fuel utilization by means of implementation of the CNFC;*
  - *Capabilities for waste minimization including recycling MA and decrease of burden on environment;*
  - *Real achievability of economic indices comparable to others energy sources;*
  - *Capabilities for provision of higher qualitative safety level by means of application of inherent SFR self-protection features and passive safety systems that permits to exclude any impact on the population and environment over the site boundaries.*

Main forms of international cooperation on SFR

- Russia participates in the international cooperation on SFR within the framework of:
  - *International Atomic Energy Agency (IAEA):*
    - ✓ IAEA Technical Working Group on Fast Reactors (Technical meetings, Coordinated Research Projects, conferences, scientific schools, educational seminars);
    - ✓ INPRO;
    - ✓ IAEA Fast Reactor Knowledge Preservation Initiative;
  - *Generation-IV International Forum (GIF):*
    - ✓ Project Arrangements within the GIF SFR System Arrangement;
    - ✓ Methodological Working Groups;
  - *International conferences (GLOBAL, ICAPP, PHYSOR, etc.);*
  - *International Science and Technology Center (ISTC);*
  - *Bilateral cooperation (France, USA, China, Japan, Republic of Korea).*

Perspective items of international cooperation on SFR

- Perspective directions of the international cooperation on SFR are:
  - *Research of safety issues including analysis of severe beyond design basis accidents;*
  - *Carrying out benchmarks for verification of computational codes on the basis of available experimental data;*
  - *Sharing of available experimental base for SFR substantiation and obtaining necessary data for development, improvement and verification of computational codes;*
  - *Implementation of joint R&D for SFR substantiation;*
  - *Development, construction and use of the MBIR as an international research center.*
- In particular, experts are aware of a necessity of creation of uniform safety criteria for SFR, especially taking into account lessons of Fukushima (such work is already initiated by the IAEA and GIF).

Thank you
for your attention !