Abstracts
Journal "Problems of Nuclear Science and Engineering. Series: Physics of Nuclear Reactors", issue No.1, 2023

The issue is dedicated to the 80th anniversary of the Kurchatov Institute and the 120th anniversary of I.V. Kurchatov and A.P. Alexandrov

UDC 621.039

To the Anniversary of the Creators of Atomic Science and Technology of the Country

A.Yu. Gagarinskiy,
NRC "Kurchatov Institute", 1, Akademika Kurchatova sq., Moscow, 123182

This article commemorates the jubilee of Igor Kurchatov and Anatoly Aleksandrov, the Founding Fathers of nuclear energy, as well as the 80th anniversary of the Kurchatov Institute, the cradle of Soviet nuclear science and engineering, the foundation of the USSR Atomic Project. The article is to remind nuclear specialists about some key historical events that have influenced the development of nuclear industry and are still relevant today.

Key Words: nuclear energy, VVER reactors, nuclear energy development strategy.

UDC 621.039

Scientific Supervision in the Developing of Nuclear Energy Based on the VVER Reactor Designs

Yu.M. Semchenkov,
NRC "Kurchatov Institute", 1, Akademika Kurchatova sq., Moscow, 123182

This article precedes the publication of the first volume of the forthcoming book "Kurchatov Institute for Nuclear Energy". It will be edited by M.V. Kovalchuk (scientific editors: Yu.M. Semchenkov and V.A. Sidorenko, compilers: A.Yu. Gagarinsky, A.V. Zhukova, M.A. Kalugin, Yu.M. Semchenkov, and V.A. Sidorenko). The book briefly describes scientific and technical challenges arising in the process of designing VVER reactors, which are resolved by the specialists of the Kurchatov Institute.

Key Words: nuclear power, strategy for development, VVER, reactor core, safety.

UDC 621.039.518.4

Advances in the Physical Startup Test Program for VVER-1200 Units

S.V. Tsyganov, Yu.A. Kraynov, A.A. Gribov,
NRC "Kurchatov Institute", 1, Akademika Kurchatova sq., Moscow, 123182

The unit 1 of the Novovoronezh NPP-2 with the first reactor VVER-1200 of the 3+ generation reached a critical state for the first time in May 2016, and the physical startup of the power unit was carried out. NRC "Kurchatov Institute" acted as the scientific supervisor of the startup of the first-of-a-kind unit with the VVER-1200 reactor at the Novovoronezh NPP-2, as well as the units of the Belarusian NPP. Five VVER-1200 units have been put into operation at present. The experience gained during the preparation and conduct of physical tests at the first units was used during the startup of the next ones. This article is devoted to the specifics of the preparation and implementation of the program of physical tests at VVER-1200 units, which was prepared and implemented by specialists from the National Research Centre "Kurchatov Institute".

Key words: nuclear reactor, VVER-1200, physical startup tests, data processing technique.

UDC 621.039.531:620.186.1

Tendencies of Structure Degradation of VVER-1000 Type RPV Steels Determining their Working Performance at Lifetimes up to 60 Years and More

E.A. Kuleshova,
NRC "Kurchatov Institute", 1, Akademika Kurchatova sq., Moscow, 123182, NRNU "MEPhI", 31, Kashirskoe highway, Moscow, 115409,
S.V. Fedotova, D.A. Maltsev, A.A. Potekhin,
NRC "Kurchatov Institute", 1, Akademika Kurchatova sq., Moscow, 123182

Changes in structure state of VVER-1000 type reactor pressure vessel (RPV) steels at extended lifetime up to 60 years and more were considered. Complex analysis of existing experimental data for changes in structure state of RPV materials under irradiation was carried out. Extended dose dependencies of the accumulation rate of radiation-induced structure elements and phosphorous grain boundary segregation are given. Type of changes of strength characteristics and critical temperature of brittleness of RPV materials due to irradiation is demonstrated. Lifetime of existing RPV steels was tentatively estimated depending on nickel content basing on study of tendencies of volume density and average sizes of radiation-induced structure elements and radiation defects changes as well as radiation embrittlement mechanisms.

Key Words: reactor pressure vessel steels, neutron radiation, phase composition, grain boundary segregation, radiation defects, radiation-induced precipitates, transmission electron microscopy, atom probe tomography.

UDC 621.039;621.039.524.441;621.039.526

Development of VVER Technology Based on Power Reactors with Light-Water Coolant of Supercritical Parameters

P.N. Alekseev, A.A. Kovalishin, A.A. Sedov, E.A. Andrianova, V.Yu. Blandinsky, V.V. Kolesov, Ya.A. Kotov, V.A. Nevinitsa, S.B. Pustovalov, S.S. Simonov, S.A. Subbotin, P.A. Fomichenko, B.I. Fonarev,
NRC "Kurchatov Institute", 1, Akademika Kurchatova sq., Moscow, 123182,
A.S. Chistov,
NNSU Lobachevsky, 23, Gagarina pr., Nizhny Novgorod, 603022,
A.N. Shmelev,
MEPhI, 31, Kashirskoye sh., Moscow, 115409

The role of VVER-SCP power reactors in the development of the light-water direction, as well as their place in the nuclear power system (NPS) and the energy supply system of Russia as a whole is shown basing on the system studies results. It is substantiated the possibility of creating a reproducible fuel base for the 45 GW (electric) NPS on the basis of nuclear power plants (NPP) VVER-SCP without commissioning of promising breeder reactors with production of odd plutonium approximately 300 kg/Pu/year/GWe with a starting load of 239Pu and 241Pu no more than 2—2.5 t/GWe and the duration of the external fuel cycle no more than 3 years (Super-BR). The possibility of creating a NPS with a capacity of up to 100 GW (electric) and more with the preservation of a reproducible fuel base based on the sharing of the VVER-SCP NPP and the Super-BR NPP in a closed nuclear fuel cycle (CNFC) is shown. The main characteristics of the VVER-SCP power reactor and NPP are given, as well as the advantages of the specific parameters of the NPP with the VVER-SCP reactor compared with analogues. The specifics of neutron physics and thermohydraulics of the reactor, thermomechanics of fuel rods, as well as neutron-thermohydraulic stability of the VVER-SCP circuit are analyzed. The main directions of researches and developments currently being carried out to substantiate the VVER-SCP technology are given. Super-BR

Key Words: light water reactor, fast reactor, pseudovapor, VVER-SKD, MOX-fuel, Super-BR, nuclear energy system.

UDC 621.039.5

RBMK Reactors. Past, Present and Future

V.N. Babaytsev, Yu.I. Zorin, A.V. Krayushkin, A.M. Fedosov, Yu.A. Tishkin,
NRC "Kurchatov Institute", 1, Akademika Kurchatova sq., Moscow, 123182

Some tasks of RBMK physics and technics, which had to be solved during the time of operation since 1973, modern reactor state and their future operation are discussed.

Key Words: RBMK reactors, LAES unit-1, void coefficient, field non-stability, chernobyl accident, uranium-erbium fuel, operation prolongation, channel bend, isotope production.

УДК 621.039;621.039.524.441;621.039.526

Development of the Physical and Technical Foundations of the Technology of High-Temperature Gas-Cooled Reactor Systems

P.A. Fomichenko, A.V. Grol, V.A. Nevinitsa, A.A. Sedov, A.L. Balanin, V.F. Boyarinov, M.A. Agulnik, V.V. Degtyarev, A.S. Ivanov, Yu.A. Veselkin, D.B. Stepennov, A.A. Bobrov.
NRC "Kurchatov Institute", 1, Akademika Kurchatova sq., Moscow, 123182

The results of a part of works carried out by NRC "Kurchatov Institute" in the development of physical and technical foundations of high-temperature gas-cooled reactor systems technology are presented. Essential components of the development of the physical and technical foundations of HTGR technology are the improvement of methodology and software for calculations to justify the nuclear physics part of the project, as well as experimental studies, such as studying the neutron-physical characteristics of reactors of this type on a critical facility, studying the tightness of fuel samples, materials science studies of samples in fuel quality control procedures. Maintaining a knowledge base on HTGR ensures the consolidation of accumulated experience and the identification of individual critical technologies, and is also used in the preparation and implementation of technological development plans aimed at obtaining design data needs.

Key Words: high-temperature gas-cooled reactor, microspherical fuel, calculational and experimental studies, knowledge base.

UDC 621.039

Container Materials for Molten Salt Reactors: Problems and Tests

A.S. Abalin, S.S. Abalin, P.N. Ivliev, V.V. Ignatyev, K.S. Klimov, A.S. Subbotin, A.I. Surenkov, I.N. Trunkin, V.S. Uglov,
NRC "Kurchatov Institute", 1, Akademika Kurchatova sq., 123182, Moscow

In view of the increased interest in molten salt reactor (MSR), the problem of choosing container materials compatible with molten fluoride salts containing a fuel additive and fission products at temperatures up to 750 ° C is considered. The results of corrosion tests of promising high-nickel alloys with a fuel salt and an intermediate coolant MSR, including an experimental results of the National Research Center "Kurchatov Institute", are presented.

Key Words*:* molten salt reactor, intergranular corrosion, nickel-molybdenum alloys, fuel salt, fission product, tellurium.

UDC 621.039

The Fusion Neutron Source as Part of a Nuclear Energy System

E.A. Andrianova, V.Yu. Blandinskii, V.D. Davidenko, M.V. Kormilitsyn, D.S. Kuzenkova, S.A. Subbotin. NRC

NRC "Kurchatov Institute", 1, Akademika Kurchatova sq., Moscow, 123182

The article considers the possibilities of a fusion neutron source with a molten-salt blanket to provide fuel for thermal fission reactors with uranium-thorium NFC, and also formulates recommendations for closing fuel nuclide balances in a nuclear power system with fission and fusion reactors.

Key Words: light water reactor, fusion neutron source, thorium, nuclear fuel cycle, molten-salt blanket.

UDC 621.039.5

Work to Provide the Power Start-up of the PIC Reactor

A.A. Ivanov, M.A. Kalugin, A.V. Krayushkin, Yu.M. Semchenkov,

NRC "Kurchatov Institute", 1, Akademika Kurchatova sq., Moscow, 123182

The PIC research nuclear reactor in Gatchina, Leningrad Region is one of the most advanced scientific complexes of the "Kurchatov Institute". The reactor is designed for neutron research in the fundamental physics, as well as for solving many applied technical problems. The physical start-up of the reactor was carried out in 2011. The power start-up of the reactor is underway since 2018. The stages of the power start-up included a large complex of calculation, design, montage and setting up works increasing the reactor power up to 100 kW and 10 MW. The power start-up with a new core is planned in 2023.

Key Words: PIC reactor, power start-up, stages, calculation justification.

UDC 621.039.58.7

Predictive Estimate of the Total Mass and Classification of RW During Decommissioning of NPP Units with VVER-1000 and VVER-440 Reactors in the Period up to 2050

B.K. Bylkin, Yu.A. Zverkov, A.S. Kolokol,

NRC "Kurchatov Institute", 1, Akademika Kurchatova sq., Moscow, 123182,

I.I. Korneev,

Joint-Stock Company "TVEL", 49, Kashirskoe sh., Moscow, 115409,

E.A. Zhurbenko,

Joint-Stock Company "TENEX", 28, bldg. 3, Ozerkovskaya nab., Moscow, 115184

The article presents the main final results of predictive estimates of the total mass and classification of radioactive waste during decommissioning of NPP units with VVER-1000 and VVER-440 reactors included in the decommissioning schedule for the period up to 2050. These estimates take into account the mass indicators of both activated and surface-contaminated radioactive waste generated during the decommissioning of NPP units with reactors of the specified type. The methodology of performing predictive estimates of mass indicators of activated and surface-contaminated radioactive waste is described. The criteria for the classification of radioactive and non-radioactive waste are given. The calculated and other initial data are described, as well as the accepted approximations used in the implementation of predictive estimates.

Key Words: NPPs with VVER reactors, decommissioning, radioactive and non-radioactive waste, activated and surface-contaminated radioactive waste, waste classification, mass indicators, methodology of predictive estimates, calculation and other initial data, accepted approximations.