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REACTOR PLANTS.
LIFE CYCLE MANAGEMENT
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Analysis of closure relations for calculating interphase friction in gas-LHMC systems

A.V. Mitskevich¹, A.O. Popov¹, A.S. Gritsai^{1,2}

¹FSUE “Alexandrov NITI”, Sosnovy Bor, Leningrad region, Russia

²Peter the Great St. Petersburg Polytechnic University in Sosnovy Bor, Leningrad region, Russia

Abstract

The paper presents results of a review of closure relations for interphase friction in gas-LHMC (liquid heavy metal cooling) two-phase systems and results of their verification against available experiment data. Two groups of closure relations are considered: the first group relations are based on a drift-flux model and the second group is based on other approaches. Also, several groups of experiments are considered: two-phase flows in small diameter pipes, large pipe flows and bubbling conditions. The study described in the paper was performed using the KORSAR computer code. The respective functionality of the code was modified to support the calculation of gas-LHMC two-phase systems. According to the results of verification there were chosen the most reliable correlations for each group of experiments. In addition, the paper’s authors propose modifications of these correlations to achieve better agreement between calculated and experimental data.

Key words: closure relations, liquid heavy metal coolant, computer code, interphase friction, two-phase flow.

Optimization of parameters of the steam generator feedwater inlet temperature maintenance system of the reactor BREST-OD-300 turbine unit

E.N. Kulakov, A.V. Popov, P.A. Kruglikov

Joint-Stock Company “I. I. Polzunov Scientific and Development Association on Research and Design of Power Equipment” (CKTI), Saint-Petersburg, Russia

Abstract

In Russia, at the JSC «Siberian Chemical Plant» site in the city of Seversk in the Tomsk region, construction of an advanced lead-cooled reactor BREST-OD-300 has begun. The use of lead imposes several regimes restrictions, one of which is the once-through steam generator inlet feedwater temperature minimum. This condition requires the use of non-standard solutions in terms of the design and composition of the secondary circuit equipment and its operating modes.

In this study, structural analysis of the steam generator inlet feedwater temperature maintenance system of the BREST-OD-300 turbine unit has been carried out. The specificity of the currently accepted parameters is noted and their optimization is proposed. The computational study showed the presence of reserves for improving the thermal efficiency of the power unit (above 1 MW) due to an increase of pressure in a direct contact feedwater heater with an increase of its bypass flow. A list of measures necessary for the implementation of the proposed technical solution has been formed, estimates of its economic effect have been given.

Keywords: NPP, turbine unit, efficiency, optimal parameters, thermal scheme, capital costs, lead coolant.

Corrosion tests in heavy water of aluminium alloys for experimental channels of the PIK reactor

*T.V. Voronina*¹, *A.A. Kaverzina*¹, *R.M. Ramazanov*², *V.I. Popov*², *S.R. Fridman*¹

¹NRC “Kurchatov Institute” – PNPI, Gatchina, Leningrad region, Russia

²NRC “Kurchatov Institute” – CRISM “Prometey”, St. Petersburg, Russia

Abstract

The work presents the results of corrosion tests of samples made of aluminium alloys AD1 and AMG3 during 6500 hours in heavy water. The analysis of heavy water chemical composition was performed at intermediate and final test stages.

The assessment of the corrosion overall rate of aluminium alloys under reactor PIK conditions was made and the growth rate of pittings located on channel surfaces was counted. The received results make it possible to extend the operational life of PIK reactor experimental channels made of aluminium alloys extra for the period up to 4 years.

Key words: corrosion research, heavy water reactor, corrosion of aluminium alloys, pitting, extension of the life of experimental channels, PIK reactor.

Requirements on ECCS sump screen performance to assure reliable pressurized water reactor core cooling in LOCA cases

I.A. Magola, L.A. Matyushev, A.G. Mitryukhin, E.L. Shamrai, R.O. Galiyev

JSC “ATOMENERGOPROEKT”, Saint Petersburg, Russia

Abstract

The paper addresses the problem of ensuring NPP safety under accident conditions, in particular, the problem of maintaining long-term core cooling by the coolant water that becomes laden with debris after a loss-of-a-coolant accident (LOCA). Requirements to the design of ECCS sump screen in relation to safety system performance are presented. It is shown that Russian nuclear power engineering does not provide well-founded sump screen design criteria with respect to the core coolability requirements.

A comparative analysis between U.S. EPR AREVA and VVER-1200 reactor cores was carried out for the potential to clog fuel assemblies with fibrous insulation debris. The possibility is evaluated of applying acceptance criteria debris limits suggested by foreign experts to the assessment of the Russian-design ECCS screen efficiency.

Key words: nuclear power plant (NPP), emergency core cooling system (ECCS), spray system, ECCS sump screen, debris, fuel assembly, spacer grid.

Experimental determination of spatial inversion point of coexisting molten phases in the U-Zr-Fe-O system

*V.B. Khabensky¹, V.I. Almjashev^{1,2,3}, E.B. Shuvaeva¹, E.V. Krushinov¹,
S.A. Vitol¹, A.A. Sulatsky¹, S.Yu. Kotova¹, V.V. Gusarov⁴*

¹FSUE “Alexandrov NITI”, Sosnovy Bor, Leningrad region, Russia

²Saint Petersburg Electrotechnical University “LETI”, Saint Petersburg, Russia

³I.V. Grebenshchikov Institute of Silicate Chemistry of RAS, Saint Petersburg, Russia

⁴Ioffe Institute, Saint Petersburg, Russia

Abstract

The work studies the stage of a severe accident associated with the formation of a molten pool and a change in the spatial arrangement of two immiscible liquid phases (metallic and oxidic) in the U-Zr-Fe-O system, which is the base system for a severe accident at a nuclear power plant. In the experiment, the initial state was a two-liquid oxidic-metallic suboxidized molten pool of corium with a bottom position of a heavy metallic liquid and a U/Zr ratio typical of the accident conditions at the Fukushima-Daiichi NPP. In the course of the experiment, in the U-Zr-Fe-O system, the mass fraction of Fe was successively increased in small portions, and the point of spatial inversion of the metallic and oxidic liquid was determined, at which the metallic liquid occupied a stable upper position in the molten pool. In the experiment, the monotectic temperature was also measured with a change in the Fe content in the melt, and the composition of the melt samples and melt products was determined. The obtained experimental results can be used to expand and refine the databases used for thermodynamic modeling of phase equilibria in multicomponent systems of molten corium at various stages of a severe accident at NPPs with pressurized and boiling water reactors.

Key words: uranium, zirconium, iron, oxygen, phase equilibria, miscibility gap, spatial inversion of liquid phases, induction melting in the cold crucible (IMCC), severe accidents.

On the feasibility of using the VBER-600 nuclear reactor in a multipurpose nuclear desalination plant to solve the problems of water supply to the Crimea and power supply to the western part of the Krasnodar territory

*E.D. Fedorovich, S.S. Makukhin, S.H. Ghazai, H. Sadeghi, E.I. Smola,
E.A. Sokolova, A.A. Kalyutik, V.A. Talalov*

Peter the Great St. Petersburg Polytechnic University, Russia

Abstract

The paper explains the choice of the VBER-600 nuclear reactor (JSC “Afrikantov OKBM” design) as a power source for a multipurpose nuclear desalination plant intended to supply fresh water to the Crimea and electric and thermal power to the western part of the Krasnodar territory.

Key words: VBER-600 nuclear reactor, multipurpose nuclear desalination plant, reverse osmosis, water supply of Crimea, power system of Krasnodar region.