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Sodium Coolant Purification Systems for a Nuclear Power Station Equipped with a BN-1200 Reactor

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Abstract—Both traditional coolant purification methods (by means of traps and sorbents for removing cesium), the use of which supported successful operation of nuclear power installations equipped with fast-neutron reactors with a sodium coolant, and the possibility of removing oxygen from sodium through the use of hot traps are analyzed in substantiating the purification system for a nuclear power station equipped with a BN-1200 reactor. It is shown that a cold trap built into the reactor vessel must be a mandatory component of the reactor plant primary coolant circuit's purification system. The use of hot traps allows oxygen to be removed from the sodium coolant down to permissible concentrations when the nuclear power station operates in its rated mode. The main lines of works aimed at improving the performance characteristics of cold traps are suggested based on the results of performed investigations.

Keywords: fast neutron reactor, sodium coolant, purification system, cold trap, hot trap, admixtures, oxygen, hydrogen, carbon, radionuclides, corrosion products, flowrate, temperature, design optimization, cooling, argon

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Maintaining the sodium coolant circulating in high-temperature nuclear power installations (NPIs) in pure state is one of the most important conditions required for securing efficient and safe operation of these installations. Along with such impurities as oxygen, hydrogen, carbon, and radionuclides, which are traditional ones for the primary coolant circuits of BN reactors, the coolant may contain a significant amount of products from corrosion of structural materials, as well as some other compounds.

The required quality of the coolant circulating in sodium-cooled loops is maintained by means of special purification devices, which use different physical principles for binding the impurities that have to be removed from sodium. At present, such methods for removing admixtures from sodium as settling, distillation, filtration, and purification by means of cold and hot traps (so-called getter purification) have been investigated and passed practical approbation.

Cold purification serves as the main method for removing impurities from the sodium circulating in the loops of operating industrial and experimental installations. Cold traps (CTs), which are used for this purpose, are heat-and-mass transfer devices serving for continuously purifying the coolant circulating through them. Flow type cold traps are used in NPIs as main devices serving for removing oxygen, hydrogen, tritium, part of structural material corrosion products, and some fission products from sodium. Different designs of cold traps have essentially different performance characteristics; therefore, investigations of CTs are aimed at optimizing their designs to achieve the best possible economic and technological indicators of these devices.

Owing to a high level of coolant temperature at which the considered installations operate, getters can efficiently be used for removing impurities from sodium. The use of hot (getter) purification of sodium circulating in the reactor coolant system by means of getter traps (HTs) can in some cases compete with the use of cold purification. Central to this method is use of the fact that at certain temperatures some substances (getters) can form strong compounds with admixtures contained in the coolant. For obtaining a higher rate of reaction between the admixture and getter, the coolant is usually subjected to additional heating.

In carrying out the analysis it was adopted that the cold trap should have a design similar to that currently used in BN-600 and BOR-60 reactors and that was applied in a BN-350 reactor. This trap must have three zones: a nonisothermal settler, a final cooling zone, and an isothermal filter. Taking into account the available experimental data and field experience gained from operation of prototypes and regular CTs, it was decided that the CT height H to diameter D ratio should not exceed 5 : 1, because at higher values of this ration the trap capacity with respect to admixtures tends to decrease. The recommended ratio of CT