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A Concept of VVER-SCP reactor with fast neutron spectrum and self-provision by secondary fuel

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In recent few years RF Concern "Rosenergoatom has promoted R&D in support of designing of innovation VVER with supercritical parameters of water coolant (VVER-SCP). Main goals of VVER-SCP have been the followings: possibility of operation of reactor in a regime of self-provision by fuel in the closed cycle; energy efficiency of NPP should be not less than 40-42%. One of VVER-SCP concepts has been a variant of two-circuit NPP with fast reactor, cooled by light-water steam of supercritical pressure –SCPS-600 with electrical power of 600 MWe. Reactor SCPS-600 has a vessel with diameter like VVER-1000, but thicker wall of 350 mm. Combination of quite tight fuel lattice and SCP steam coolant (with the inlet/outlet reactor temperatures of 388oC and 500oC respectively and pressure of 24.5 MPa) allows realizing quite fast neutron spectrum in the core. The core is formed with three groups of Fuel Assemblies with different content of PuO2: 16, 18.5 and 24% weight respectively. Butt and side blankets comprise dioxide of depleted uranium with content of 235U of 0.2%. Central zone of the core consists of the ThO2 fertile fuel that provides appropriate void reactivity coefficient. With a load of 32.3 m.t. of heavy atoms the averaged burnup in reactor amounts 54.2 MW-days/kgha. The ratio of unloaded-to-loaded fissile atoms in reactor amounts 1.01 –1.03 that make it possible to get the regime of self-provision of reactor by its own secondary fuel in the equilibrium closed fuel cycle. In the secondary circuit of the installation it is planned to use a quite compact supercritical steam turbine with intermediate steam separation without overheating. The steam going from Steam Generator to the turbine has pressure of 23.5 MPa and temperature of 480oC. Net efficiency of the turbine installation amounts 42.5%. The paper considers effect of the design and technology solutions upon the main neutron-physics and thermal characteristics of the reactor. Special care is taken to ways of lowering a positive void reactivity effect by decreasing of parasitic neutron absorption in the core due to thinner cladding, use of new structure materials, like ferritic-martensitic steels and SiC, use of different variants of the spatial distribution of ThO2 and solid moderators (like ZrH2 and BeO) in the core.

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