SCW convection loop for materials assessment for the next generation reactors

Description

The Technological Roadmap for Generation IV Nuclear Systems (G-IV) includes R&D of construction materials for the Super Critical Water Reactor (SCWR) that uses supercritical water as a coolant. Experimental data on the corrosion and stress corrosion cracking of construction materials in the supercritical water (SCW) under irradiation are currently absent. The SCW properties under irradiation are not investigated in detail. Turbulent and laminar flows of the SCW under irradiation are not described in accessible literature. Some results of R&D of construction materials in SCW are obtained using convection loops without irradiation. However, this experience is insufficient for designing and construction of the SCWR.

The current Project is devoted to design and construction of a SCW convection loop with test cell under electron irradiation. Reactor radiation and temperature fields will be simulated in this test device.

Innovative Aspect and Main Advantages

One of the nuclear systems considered within the Generation IV initiative is the Super Critical Water Reactor (SCWR) that uses supercritical water as a coolant. SCWR belongs to the next (after ACR) generation of CANDU reactors. In Canada, as the evolutionary step of CANDU technologies development, a pressure tube design for SCWR is selected. Along with evident efficiency of reactors with pressure of about 25 MPa and outlet coolant temperature up to 550°C, no proper experience of materials assessment for SCWRs is stored. Thus, R&D of materials for SCWR is needed. Along with in-pile convection loops for corrosion and mechanical tests of materials, rather promising are tests of materials in SCW under electron irradiation. The advantage of this type of experiments even over material tests in in-pile loop is that, from one hand, intensity of e- and γ - irradiation produced by an electron beam can be made larger than that in SCWR. It can be easier controlled. From the other hand, there is radiolysis of SCW, laminar and turbulent flow control, transition from subcritical to supercritical state, etc. For this reason, a convection loop with electron irradiation cell for R&D materials for SCWR is a rather promising test facility. Evidently, the cost of such tests will be considerably lower than that for in-pile loops.

In the Kharkiv Institute of Physics and Technology (KIPT) a methodology for simulation electron irradiation and follow-up tests has been developed and used to simulate effects of reactor irradiation on corrosion and composition of Ni-Mo alloys in molten fluoride salt at a temperature of 650°C which are considered advanced materials for Gen IV molten salt reactors.

Areas of Application

The Canada-Ukraine Electron Irradiation Test Facility (CU-EITF) will be used for tests of construction materials for Gen III+ and Gen IV reactors belonging to the CANDU family (e.g., ACR, SCWR).

Stage of Development

Development phase. Feasibility study.

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