Fission products deposition mechanism on the stainless-steel structure surface of the sodium cooled Fast Breeder Reactors based on DVX-α method

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JNES: Japan Nuclear Energy Safety Organization, JNES, supports the safety review of the national regulatory authorities based on the accidents analysis and risk assessments in order to improve the safety of nuclear power plants including the sodium cooled fast breeder reactor (FBR) such as MONJU. For providing technical supports to the regulatory authorities, JNES develops and maintains analysis codes by taking account the up-to-date knowledge of the microscopic methods such as MO and MD approaches.

ACTOR CODE: From the view point of a plant risk assessment against severe accidents, the evaluation is very important for the transfer mechanism of fission products (FPs) that are released from the disrupted fuel to the sodium of the primary heat transfer system of FBRs. The ACTOR code is developed to simulate the FP transport mechanism such as from the degraded fuel to the coolant sodium, fluid dynamics within sodium, an adsorption and desorption behavior on the wall structure surface, and release to the cover-gas space.

ADSORPTION/DESORPTION MODEL: The FP atoms dispersed in the sodium flow deposit on the stainless steel surface through the following two-step process: i) mass transfer of nuclides by diffusion from the coolant bulk flow to the boundary layer above the steel surface, and ii) adsorption and/or desorption processes on the steel surface. In the ACTOR code the deposition rate constant Ji for the nuclide i is descried by {Ji}={Ki}{Si}{Ci}, where theoretical deposition rate constant Ki based on the diffusion model, experimental sticking coefficients Si, and FP concentration Ci in the coolant bulk flow. The experimental sticking coefficient Si is obtained by the FPL-II test using the in-pile sodium loop of the TTR reactor [1]. As shown in Fig. 1(1), it is found that sticking coefficients of non-volatile FPs (Sr, Y, Nb, and Mo) is extremely lager than those of volatile FPs (Rb, Sb, I, and Cs).

INTERPRETATION OF STICKING COEFFICIENTS BY USING DVX-α: In order to understand the relationship of experimental sticking coefficients and electronic interaction between FP atoms in sodium flow and Fe atoms arranged on the structure surface, the DVX-α calculation has been conducted. The results indicate that i) larger sticking coefficients of the non-volatile FPs are attributed to the ionic-bonding state of FP-Fe system causing an irreversible chemical adsorption as shown in Fig 1(2), ii) smaller sticking coefficients of the volatile FPs are attributed to the covalent-bonding state of FP-Fe system causing a reversible physical adsorption as shown in Fig 1(3), and iii) the DVX-α method will be useful tool to evaluate the theoretical sticking coefficient for which the experimental observation cannot be conducted.

References

[1] H. Endo, T. Sakai, N. Miyaji, and K. Haga, "Deposition Mechanism of Fission Products on Stainless Steel Surface". BNES Conf. on Science and Technology of Fast Reactor Safety, (1986) 153.

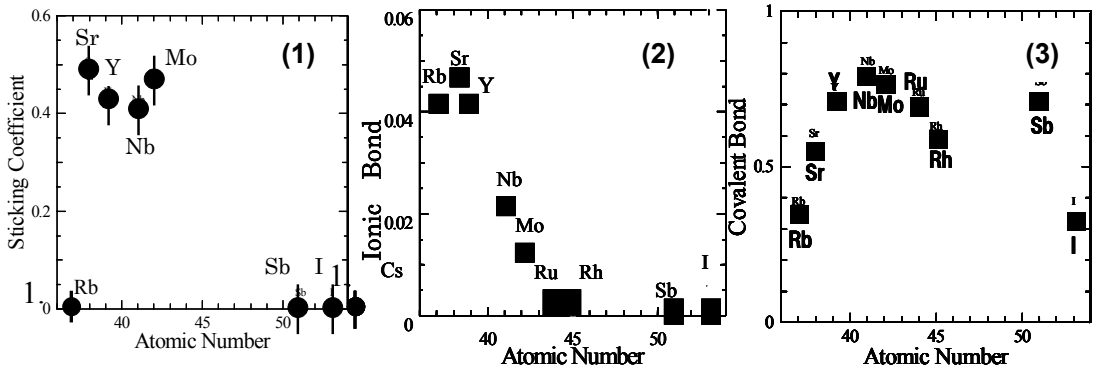

Fig.1 Sticking coefficients by FPL-II test(1), Ionic bonding component (2) and Covalent bonding component(2) by DVX-α