ML6: Combined effect of molten fluoride salt and irradiation on Ni-based alloys

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Fluid fuel (in form of molten fluoride salts) is considered as a promising non-traditional fuel in several projects of the Generation IV Nuclear Systems (G-IV), e.g. transmutors and thorium reactors. Molten salts (MS) are candidate coolants for high temperature reactors to produce electricity and process heat for hydrogen production. Thus the MS has to be compatible with piping and heat exchanger materials. A challenge for using molten fluoride salts is their corrosive nature. R&D of construction materials compatible with MS at high temperature is the key problem of the G-IV projects.

Ni-Mo alloy (Hastelloy N) was used in MS experiment in Oak Ridge many decades ago. This experience was promising but it is not enough for designing of constructions and use of the proposed G-IV reactors for a long time. Some investigation of role of alloying additions on the Ni-based alloy corrosion in convective MS loop were performed later but combined effect of MS and irradiation on Ni-based alloys was never investigated before experiments performed in National Science Center "Kharkiv Institute of Physics&Technology". The lecture is dedicated to the experiment methodology and results obtained.

To perform the experiment, Electron Irradiation Test Facility (EITF) was designed, constructed and used with a linear electron accelerator of 10 MeV energy. The electron irradiation was chosen for the following reason. Since the corrosion is controlled by chemical reactions and the reaction rate is rather sensitive to the local energy deposition due to irradiation, the electron irradiation which provides a variety of deposited energy values in surface layers of the tested samples is an efficient instrument for imitation of the reactor irradiation. In parallel, the electron irradiation impacts diffusion and phase transformations in bulk and, especially, within the grain boundaries.

Two Ni based alloys differing in composition by dopants Nb (0. 5%) and Y (0. 05%) were tested using EITF. Both alloys possess acceptable corrosion resistance but the corrosion rate under irradiation is some orders in magnitude higher than that without irradiation. Investigation of the role of Nb and Y dopants in Ni-Mo alloys on the corrosion under electron irradiation at 650° C shows that they change both the character of the corrosion and the corrosion rate sensitivity to the energy deposited.

Carbon-carbon composites were tested as well. They showed rather high corrosion and irradiation resistance in MS.

To conclude, the R&D to be conducted, in collaboration between nuclear physicists, condense matter physicists and metallurgists, will be discussed, pointing out the key issues to solve in order to demonstrate the feasibility of G-IV projects.