SiCf/SiC cladding for LWR: Assessment of flow accelerated corrosion

Brice BOURDILIAU[1], Frédéric DATCHARRY[1], Max HÉLIE[1], Marion LE FLEM[1], Christophe LORRETTE[2]

[1] CEA, Den-Service de Corrosion et du Comportement des Matériaux dans leur Environnement (SCCME), France

[2] CEA, Den-Service de Recherches Métallurgiques Appliquées (SRMA), France

To improve the tolerance of the fuel towards accidental scenarios of light water reactors (LWR), such as the one encountered at Fukushima event, an extensive R&D is performed by the French Alternative Energies and Atomic Energy Commission (CEA) in the framework of the French Nuclear Institute with FRAMATOME and EDF. In particular, fuel cladding constituted of silicon carbide continuous fiber ceramic matrix composite materials (SiC_f/SiC) is considered as a long-term option besides evolutionary designs (e.g. Cr-coated cladding [1]).

The outstanding mechanical behaviour of SiC_f/SiC cladding tubes at high temperature and their low oxidation rate, resulting in reduction in hydrogen generation, has been previously reported both in LWR operating conditions and in high temperature steam conditions [2,3]. However, after exposure in autoclaves, some recession of the SiC was detected. Even if it remains limited, this raises the question of the cladding dissolution, the resulting pollution of the primary loop by silicium-base species and the effect of the water flow on these phenomena.

The present work reports the preliminary result obtained in a corrosion loop especially developed at CEA to address the flow accelerated corrosion of SiC/SiC cladding tubes. The device FACETT (Flow Accelerated Corrosion Experiments for Tube Testing) allows to investigate four 50-mm-long tubes in PWR primary loop conditions (350°C, appropriate chemistry) and with water flow of 4 $m.s^{-1}$. Sampling of the media can be performed to follow the chemistry change. The results will include weight loss measurements, surface examination and chemical analyses after a 5month-exposure of CEA-made SiC_f/SiC cladding tubes.

[1] Bischoff et al., AREVA NPs enhanced accident-tolerant fuel developments: Focus on Cr-coated M5 cladding, Nuclear Engineering and Technology 50, 2 (2018) 223-228

[2] C. Lorrette et al., SiC/SiC composite behavior in LWR conditions and under high temperature steam environment, proceedings of TopFuel 2015, Zurich, Switzerland (Sept. 13-19, 2015)

[3] C. Lorrette et al., Quench behavior of SiC/SiC cladding after high temperature ramp under steam conditions, proceedings of TopFuel 2017, Jeju Island, Korea (Sept. 10-14, 2017)