Pitting Potential of Zircaloy-2 in Artificial Seawater under Gamma-ray Irradiation

Takafumi MOTOOKA, Atsushi KOMATSU,
Takashi TSUKADA and Masahiro YAMAMOTO
Japan Atomic Energy Agency
2-4, Shirane, Shirakata, Tokai-mura, Naka-gun,
Ibaraki-ken, 319-1195 Japan

Zircaloy-2 (Zry-2) spent nuclear fuel cladding has been widely used in Boiling Water Reactors. In the Fukushima Daiichi nuclear power plant, seawater was poured into spent fuel pools for emergency cooling. Spent nuclear fuels are radioactive. The irradiation might affect pitting corrosion behavior of Zry-2 in water containing seawater salts.

In this report, pitting potential of Zry-2 in water containing seawater salts was measured as a function of chloride concentration and temperature under gamma-ray irradiation.

Gamma-ray irradiation was conducted in the ^{60}Co irradiation facility in Japan Atomic Energy Agency. Polarization curves were obtained to measure the pitting potential of Zry-2. Some samples were oxidized in air at 288ºC for 72h to form a thick oxide film. Spontaneous immersion potentials were measured to evaluate the possibility of pitting corrosion. Working electrode was a Zry-2 cladding tube, reference electrode a platinum plate, and reference electrode a Ag/AgCl saturated KCl (SSE). Scan rate was 0.167 mV/s. Spontaneous immersion potential after 1h immersion was defined E_{sp} in this report.

Anodic polarization curves of as polished Zry-2 in artificial seawater (ASW) with and without gamma-ray irradiation at 500Gy/h are given in Fig.1. Passive current density was greater under irradiation than un-irradiation. Passivity breakdown with suddenly current density rise was observed around 0.2 V vs. SSE in both conditions. Difference in pitting potential with and without gamma-ray irradiation was small.

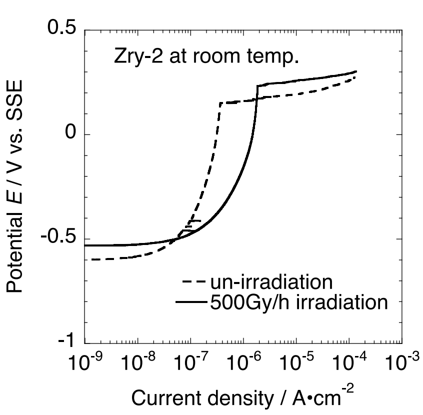

Fig.1 Anodic polarization curves of as polished Zry-2 in ASW with and without 500Gy/h gamma-ray irradiation at room temperature.

Figure 2 shows pitting potential (E_{pit}) of as polished Zry-2 in normal and diluted ASW at a dose rate of 500Gy/h gamma-ray irradiation at room temperature. E_{pit} decreased with increase of salt contents in solutions. As main aggressive anion was chloride ion, it suggested that pitting potentials depended linearly on the logarithm of the chloride ion concentration. The difference between E_{sp} and E_{pit} was more than 0.5 V.

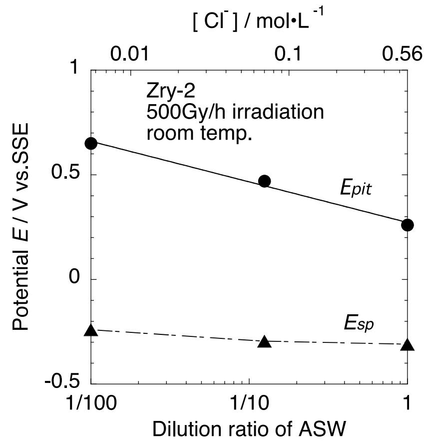

Fig.2 Pitting potential of as polished Zry-2 in normal and diluted ASW under 500Gy/h irradiation at room temperature.

Figure 3 shows pitting potential of Zry-2 with and without oxide films in ASW under 500Gy/h gamma-ray irradiation at room temperature. E_{pit} depended on temperature. Oxide film formed by heat treatments affected pitting potential. E_{sp} of Zry-2 pre-oxidized in air at 288ºC was nobler than E_{pit} of as polished Zry-2 (without oxide film). It suggests that the oxide film is an important factor to susceptibility to pitting corrosion.

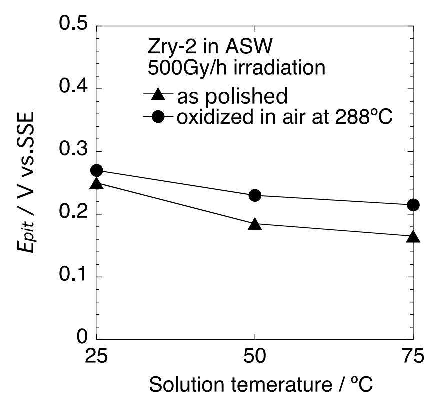

Fig.3 Temperature dependence of pitting potential of Zry-2 with and without oxide film under 500Gy/h irradiation.

Measurement of spontaneous immersion potential as polished Zry-2 with and without gamma-ray irradiation was conducted for 30 days at room temperature. The spontaneous potential was nobler with irradiation than without irradiation during immersion. The spontaneous potential in 30 days did not exceed E_{pit}.