Pt deposition behaviour in boiling water reactors: the NORA project

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Introduction: Principle of SCC mitigation by NMCA

Major cause of materials degradation in BWRs: SCC

Mitigation of SCC in piping and reactor internals

Reduction of electrochemical corrosion potential (ECP)

Hydrogen water chemistry (HWC)
(6 of 19 European BWRs, 35 of 35 US BWRs)

Main steam line radiation increase
(release of N-16)

NMCA/NobleChem™

[Adapted from S. Hettiarachchi, et al., 7th Int. Conf. on Nucl. Eng., 1999]
Injection of noble metal compounds into reactor water (NMCA/NobleChem™)

Deposition of Pt particles on water-wetted surface of structural materials

Catalytic surface → faster and better recombination of $\text{H}_2$ with $\text{O}_2$ & $\text{H}_2\text{O}_2$

$\text{O}_2/\text{H}_2\text{O}_2$ conc. on the surface $\approx 0$

(if stochiometric $\text{H}_2$ excess)

Low ECP

($\approx$ “SCC mitigation”)

[P.L. Andresen, Y.J. Kim, 15th Env. Degradation Conf., 2011]
Application of NMCA in BWRs in Europe & USA (2014)

**European BWRs:**
6 x HWC, 3 x OLNC

**US BWRs:**
35 x HWC, 3 x NMCA, 29 x OLNC
The NORA project

- **NORA:**
  Noble metal deposition behaviour in boiling water reactors

- **Main objective:**
  Gain phenomenological insights and a better basic understanding of the Pt distribution and deposition behaviour in BWRs.

- **Duration:** January 2010 – August 2016

- **Project partner:** ENSI, KKL, KKM

- **Project coord.:** S. Ritter (LNM)

- **Involved personnel:**
  P.V. Grundler (LNM), L. Veleva (AHL),
  S. Abolhassani-Dadras (LNM), B. Baumgartner (LNM),
  H.P. Seifert (LNM), I. Günther-Leopold (AHL), N. Kivel (AHL), P. Reichel (AHL),
  J. Kobler-Waldis (AHL), A. Ramar (AHL)
  H. Glasbrenner (ENSI), G. Ledergerber (KKL), Ch. Weber (KKM)
Assessment of the Pt distribution behaviour

Exposure of SS specimens in a HTW loop at PSI

Exposure of SS specimens in the MMS & RWSL at KKL

Analysis of the Pt deposition on SS specimens by:
SEM, TEM, EDX, LA-ICP-MS
(Pt particle size, distribution, concentration)

Assessment of the Pt distribution behaviour
Experimental techniques for analysis of the Pt deposition

The specimens from the HT water loop (and from KKL) were analysed by:

- **Field Emission – Scanning Electron Microscopy:**
  - Secondary electrons – topography
  - Back scattered electrons – Z-contrast
  - In-lens secondary electrons – topography
  - EDX for chemical analysis

- **Transmission Electron Microscopy:**
  - Diffraction contrast imaging
  - EDX for chemical analysis

- **Mass Spectrometry (quantitative analysis):**
  - Laser Ablation – Inductively Coupled Plasma – Mass Spectrometry
Example of Pt treated specimens

[Image of SEM micrograph showing Pt treated specimens]