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# High temperature corrosion of cooling pipelines in nuclear reactor: the interfacial elastic deformation of oxidized layer

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The corrosion of cooling pipelines in nuclear reactors has several attributes, mainly comprising the (electro)chemical aspects. The use of corrosion-resistant zirconium Zr as a clad in nuclear reactors still sets limitations on the reactor's fuel energy extraction rate in high temperatures 1 and humidity 2 which could lead to degradation [3, 4] and possibly fracture [5]. The mechanisms of corrosion have extensively been investigated [6], which is still ongoing using new techniques such as additive manufacturing [7].

In this work, a new constitutive paradigm is developed for swelling-based deformation during the corrosion as an internal drive for the mechanical mismatch between oxide–metal binary medium, which is distinguishable from typical research in mechanics involving an external event (i.e. loads/displacements). In this regard, forming equilibrium between the larger oxide and smaller metal compartments, the non-linear evolution in the total swelling is properly formulated versus the progress scale of the corrosion. The generated strains and the following stresses have been obtained for two cases of thin oxide films (i.e. 1D) and thick oxide layers (i.e. 2D), which involve both elastic deformation (i.e. reversible) and plastic corrosion (i.e. irreversible) events. The verification has been performed by tracking the formed radius of curvature from both perspectives of modelling and finite elements simulations. Furthermore, the dominant parameters for the formation of the metallic strain as well as the total swelling have been addressed. Consequently, the sensitivity of the interfacial mismatch stresses has been analytically explored versus the ratio of the elastic moduli and molar volumes. The developed swelling-induced mismatch paradigm could be used either as an indicator for the criticality of the corrosion extent, the corrosion-initiated mechanical actuation, or the material selection process for design in corrosion-prone environments, based on the volume-sensitive and mechanical properties.

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**Primary authors:** ARYANFAR, Asghar (Bogazici University); GODDARD III, William (California Institute of Technology)

**Presenter:** ARYANFAR, Asghar (Bogazici University)

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