ADVANCES IN PERIDYNAMIC MODELING OF ENVIRONMENTALLY-ASSISTED CRACKING

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Corrosion, oxidation, temperature, and humidity changes can lead to changes in material properties and induce deformations and defects that produce premature fracture and failure in a host of materials and structures. These physical processes have been difficult to simulate computationally and predictive models have been sought for many decades. Peridynamic models introduced recently offer a path towards building our predictive capabilities in modeling fracture, damage, and complex multi-physical changes in materials that lead to failure. I will present some recent developments on localized corrosion, SCC, and temperature/oxidation/drying-induced fracture in a variety of materials (metals, ZrC, concrete). Crevice and galvanic corrosion are particularly dangerous types of localized corrosion that can rapidly lead to fracture and catastrophic failure. Computational modeling of crevice corrosion, for example, is complicated by the extreme aspect ratio of crevices (long and narrow spaces). The peridynamic model for crevice corrosion introduce in [1] predicts, to great detail, the evolution of corrosion attack in crevices, and explains their strange behavior (Fig. 1). In galvanic corrosion, high corrosion rates are induced near the metal-metal interface and accurate representation of the electric potential is critical in obtaining predictive results. Our recent results have shown that classical models require an artificial step be created in the geometry of the galvanic couple in order to obtain results similar to those seen in experiments [2]. Without this artifice, results from classical models of galvanic corrosion produce misleading smooth damage profiles, hiding potentially dangerous sharp corrosion attack that could easily trigger crack growth and catastrophic failure. With it's very general mathematical formulation that avoids using spatial derivatives sensitive to non-smooth geometries, the peridynamic (PD) model for galvanic corrosion finds the correct damage profiles caused by galvanic corrosion without having to artificially modify the sample's geometry. I will also present results on failure in concrete caused by corrosion or temperature/humidity variations, oxidation-induced fracture in ZrC at high temperatures, and some recent results with a new, fast convolution-based method for PD models of corrosion and fracture, able to consider hundreds/thousands of growing pits and samples sizes in the mm/cm scale (see Fig. 2).

References:
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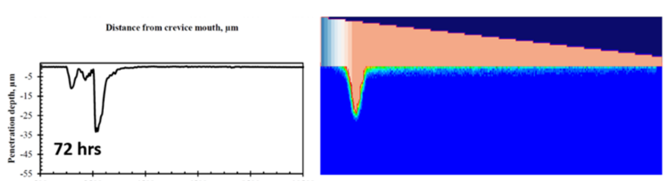

Figure 1 – Crevice corrosion from experiments (left) and peridynamic simulation (right)after 72 hours of corrosion.

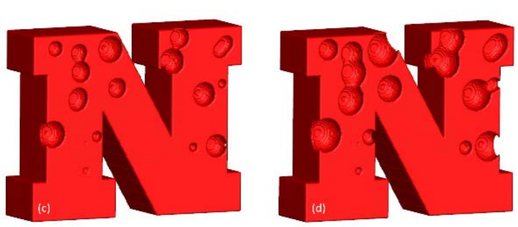

Figure 2 – Autonomous evolution of pitting corrosion with the FCBM-PD model