Fundamental Understanding of Pipeline Material Degradation under Interactive Threats of Dents and Corrosion

U.S. Department of Transportation
Pipeline and Hazardous Materials Safety Administration

Amir Abdelmawla[1], Kaustubh Kulkarni[2], Kurt Hebert[3], Ashraf F. Bastawros[1]
[1]Department of Aerospace Engineering, [2]Department of Mechanical Engineering,
[3]Department of Chemical and Biological Engineering,
Iowa State University, Ames, IA 50011.

Iowa State University College of Engineering

Main Objective

Evaluate interactive threats of external mechanical dents and secondary features, through integrated lab-scale experimental and numerical framework to characterize and better predict the remaining safe life and operating pressures, while projecting the needs for mitigation measures.

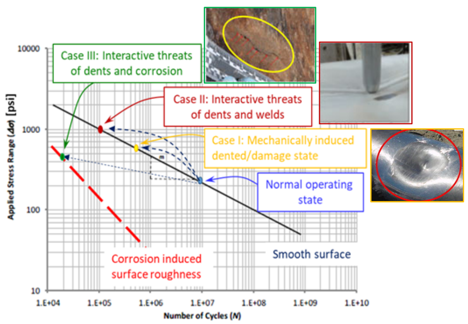

Figure 1. Hypothesized interactive threats effects on the fatigue life of the pipeline material.

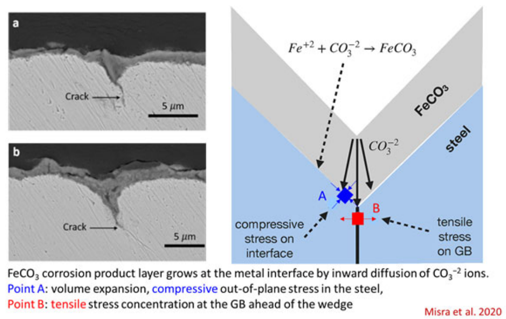

Figure 2. Role of electrochemistry on GB cracking Evolution

Project Approach/Scope

Provide detailed understanding of the material strength and toughness under interactive threats of (a) dents (especially plain dents) and (b) progressive corrosion environment. Reduce variance in predicting failure limits and/or remaining fatigue life.

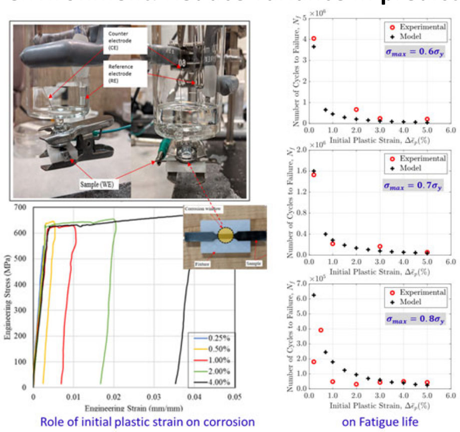

Figure 3. Coupled micro-electrochemo-mechanical experimental setup (plastic damage/corrosion and/or fatigue).

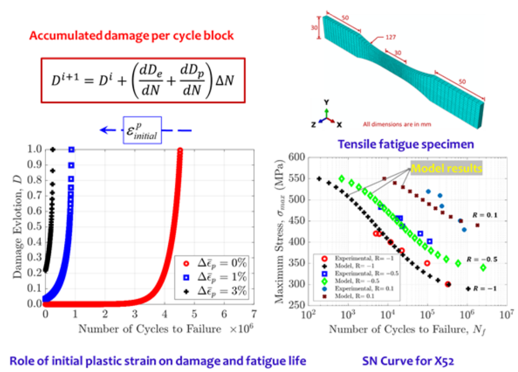

Figure 4. Elasto-plastic fatigue damage modeling (dent strain calibration, ASME B31.8 calibration)

Expected Results or Results to Date

Identify Physics of Interactive Threats: Provide fundamental understanding of measurable degradation parameters at the local level, that can assist in the variance reduction of threat assessment of the damage at the pipeline structure scale.

Model Based Prediction: Provide lab-scale experimentally calibrated framework.

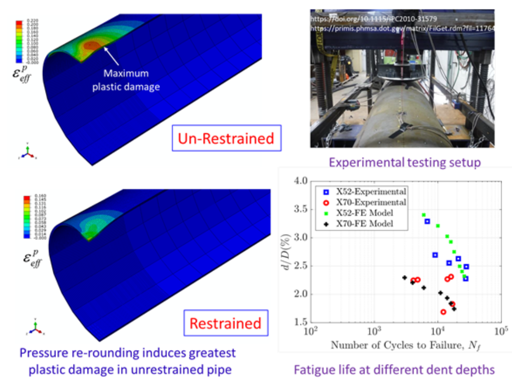

Figure 5. simulation results for the role of restrained vs. unrestrained gauge on fatigue life. (Cumulative elasto-plastic damage, X70)

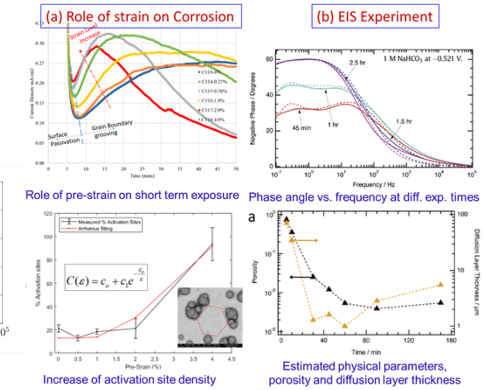

Figure 6. (a) Role of initial plastic strain on corrosion. (b) EIS phase shift evolution on corroded X70 steel and the derived physical properties

Acknowledgments

This project is funded by DOT/PHMSA's Competitive Academic Agreement Program No. 693JK31950003CAAP.

References

1. P Mishra, D Yavas, A Alshehri, P Shrotriya, A Bastawros, KR Hebert, 2021. "Model of vacancy diffusion-assisted intergranular corrosion in low-alloy steel," Acta Materialia 220, 117348
2. D Yavas, T Phan, L Xiong, KR Hebert, AF Bastawros, 2020. " Mechanical degradation due to vacancies produced by grain boundary corrosion of steel," Acta Materialia 200, 471-480
3. P Mishra, D Yavas, AF Bastawros, KR Hebert, 2020. "Electrochemical impedance spectroscopy analysis of corrosion product layer formation on pipeline steel," Electrochimica Acta 346, 136232
4. D Yavas, P Mishra, A Alshehri, P Shrotriya, AF Bastawros, KR Hebert, 2018. "Morphology and stress evolution during the initial stages of intergranular corrosion of X70 steel," Electrochimica Acta, 285, 336-343

Public Project Page

Please visit the below URL for much more information:

https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=838