Scaling Factors and Self-Sensing in Composite Repairs of Corrosion Defects

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

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Main Objective

This project was awarded to The University of Tulsa in order to resolve two fundamental questions regarding the composite repair approach to damaged pipelines: do scaling effects have an impact on repair performance? And how can an operator effectively inspect these repairs during their design lifespan?

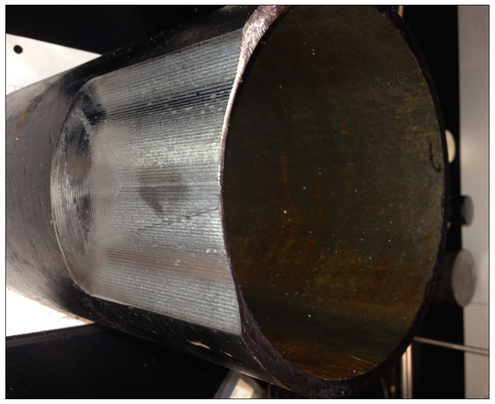

Figure 1. Example of machined defect simulating an 80% wall loss.

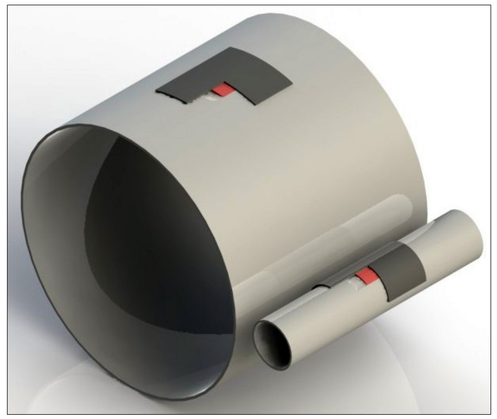

Figure 2. Comparison between the desired repair size and the current test standard.

Project Approach/Scope

To test scalability of repairs, full-encirclement repair geometry (Fig. 3) a patch repair geometry (Fig. 4) will be applied to small scale (6.625 in OD) and large scale (36 in OD) pressure vessels. These vessels will be pressure fatigue tested from 0 to 72% MAOP. Results from the large scale and small scale tests will be compared to identify any scaling issues that should be addressed in the repair standards.

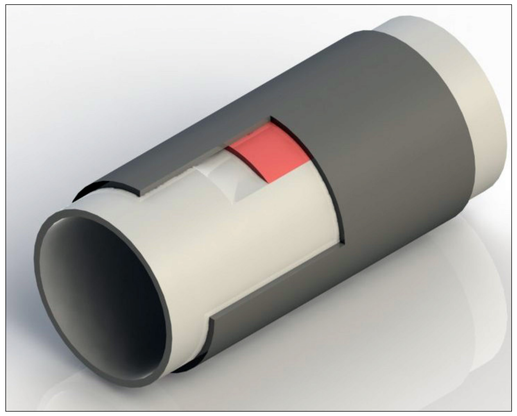

Figure 3. Rendering with a cutaway of a full circumferential repair system.

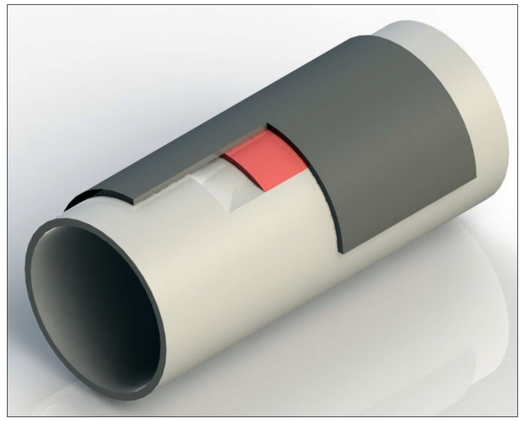

Figure 4. Rendering with a cutaway of a patch repair system.

Expected Results or Results to Date

The testing will provide data relating the behavior of full encirclement repair systems to patch repair systems. Initial Finite Element Analysis (FEA) simulations have been performed to understand the impact of reducing the circumferential extent of the repair on substrate stress and strain. While the deformed shapes of the full-encirclement and patch repair are considerably different (compare Figs. 5 and 6) the strain levels in the defect region for the repair and the substrate are comparable. This initial result indicates that the two repair methodologies should perform similarly, at least in terms of defect performance during fatigue. Experimental testing will begin later this year to confirm these computational results.

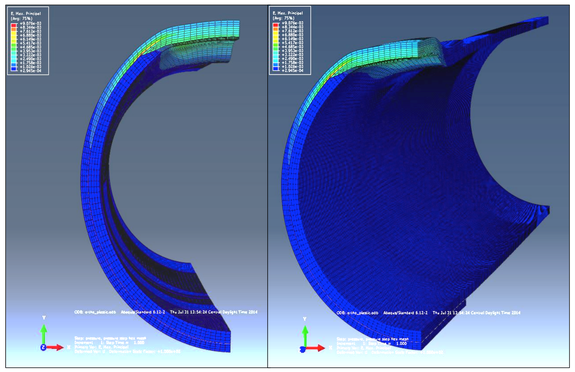

Figure 5. FEA simulation of defect with a full encirclement repair.

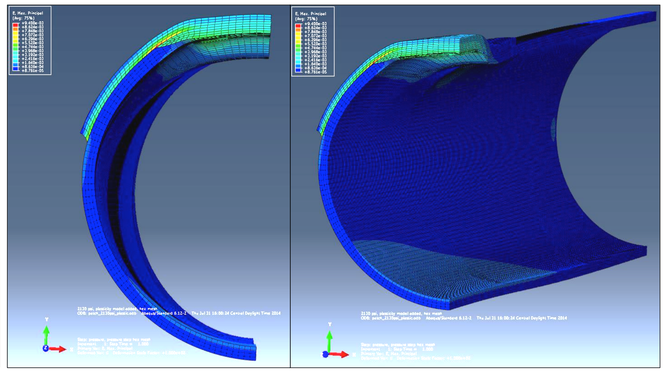

Figure 6. FEA simulation of a defect with a patch repair.

Acknowledgments

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References

C. Alexander, "Developing stress intensification factors for composite repair systems used to repair damaged pipe," 2010, pp. 283-292.

M. R. Kessler, R. H. Walker, D. Kadakia, J. M. Wilson, J. M. Duell, and W. K. Goertzen, "Evaluation of carbon/epoxy composites for structural pipeline repair," 2004, pp. 1427-1432.

Public Project Page

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