Failure simulation and reliability assessment of PA-11 gas pipeline

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Main Objective

This project was awarded to Arizona State University (sub through CU Denver) for the reliability assessment and prognostics of pipelines. A general methodology based on failure mode analysis, advanced numerical simulation, and probabilistic methods will be developed for accurate and efficient pipeline reliability assessment. The developed methodology will be integrated with damage diagnosis techniques for the prognostics and health management of pipeline systems.

Figure 1. Failure modes of pipelines

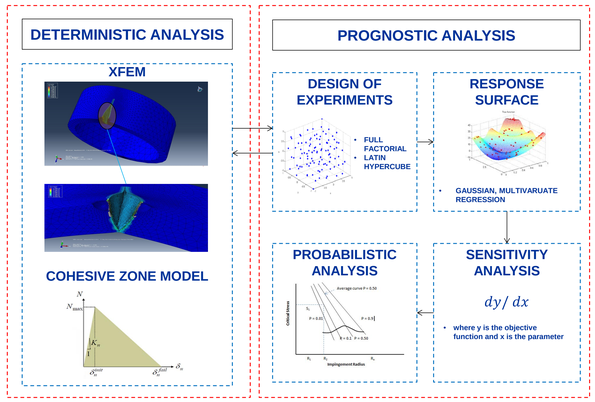

Figure 2. Project Reliability Assessment Methodology

Project Approach/Scope

- Extended finite element method (XFEM) and cohesive zone modeling (CZM) for the physics-based failure simulation;
- Design of experiments with advanced sampling technique, Gaussian process modeling, and Monte Carlo simulation for the reliability estimation;
- Integrated damage diagnosis (CU Denver) and prognosis (ASU) for the health management of pipeline systems.

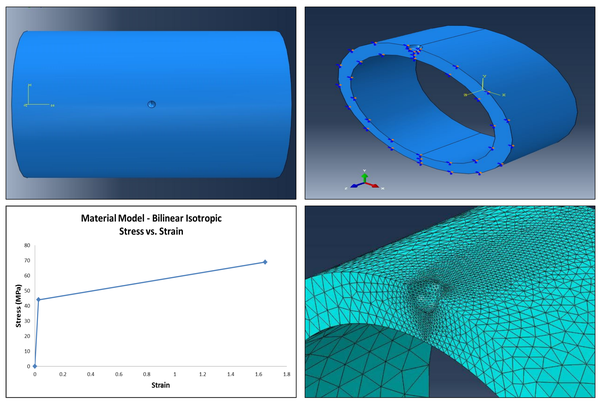

Figure 3. XFEM model

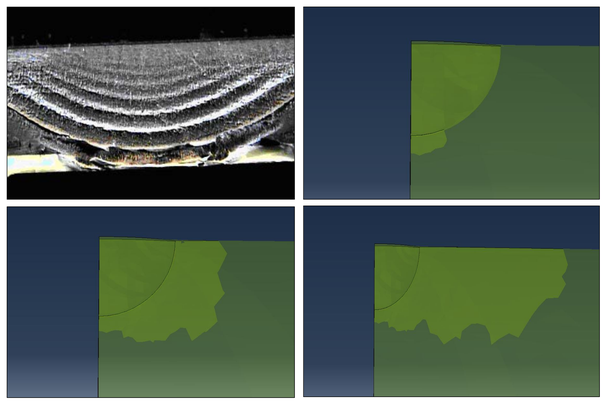

Figure 4. Slow Crack Growth simulation results

Expected Results or Results to Date

The proposed XFEM and CZM methodology can successfully simulate the pipeline cracking due to rock impingement. The model parameters are calibrated using available experimental data. The splitting crack propagation along the pipeline axis direction is identified as the dominate failure mode. Detailed parametric studies haven been performed to investigate the effect of the pipe diameter, wall thickness, rock impingement size, and operational pressure of the final failure load. One of the observation made was that XFEM and CZM technique is highly mesh sensitive. Additional numerical and experimental studies are required to further improve the proposed simulation framework.

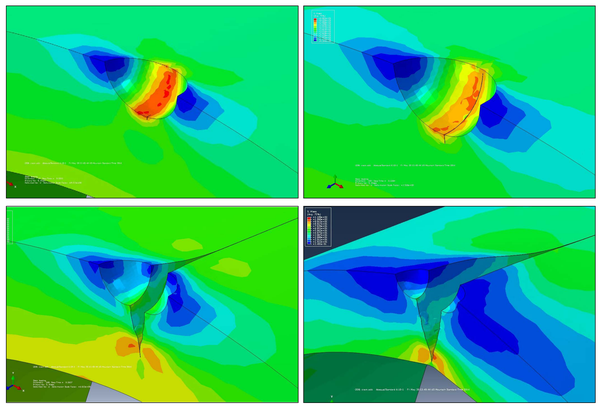

Figure 5. Crack propagation through length

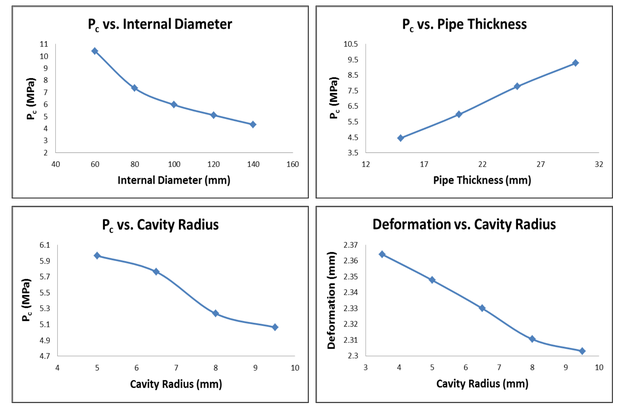

Figure 6. Parametric studies

Acknowledgments

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References

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2. Plastic Pipe Failure, Risk, and Threat Analysis – GTI Report
3. Fracture simulation of co-continuous composite materials under static loading: Tahir, F. , Liu, Y. , Wang, L. - 56th AIAA Scitech Conference.

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