

Title: Fatigue Life and Fracture Assessment of Piping Components under Operating Conditions

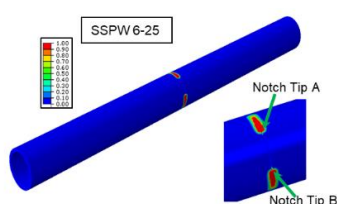
Duration: April 2023 to March 2026

Objectives:

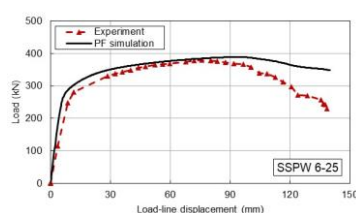
- Fracture assessment of piping components using energy-based model
- Remaining fatigue life evaluation of straight pipes under combined bending and torsion
- Fracture assessment of welded pipes under monotonic and cyclic loading
- Remaining life assessment of pipes with combined defects subjected to cyclic internal pressure
- Development of models for crack growth and residual strength prediction of piping components under variable amplitude loading
- Numerical investigations on crack growth prediction of piping components using cohesive zone modelling
- Development of AI/ML based model to estimate the fracture parameters and fatigue life of piping components

Progress Highlights:

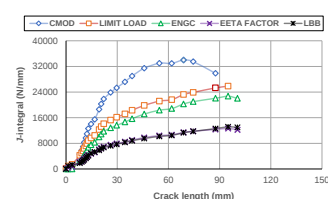
- ❖ Phase field methodologies for prediction of fracture behaviour of piping components and validation with the experimental observations
- ❖ Crack growth resistance (J - R) curves for notched pipe specimens subjected to static monotonic and cyclic loading using different analytical approaches
- ❖ Estimation of plastic zone size using analytical, experimental and numerical approaches for various load and crack configurations
- ❖ Numerical simulation of fracture behaviour of through-wall notched piping components under elevated temperature using energy-based model
- ❖ Fatigue crack growth studies on straight pipes with circumferential part-through notch under combined bending and torsional loads
- ❖ Evaluation of mechanical and fatigue crack growth properties of API 5L X46 grade steel in inert environment
- ❖ Fatigue life evaluation of typical pipeline of oil and gas industry under variable amplitude loading



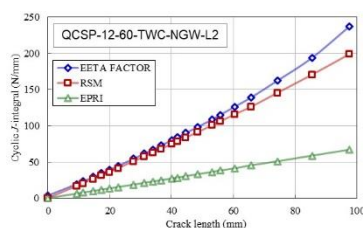
Numerical simulation of fracture behaviour of piping component



Comparison of load vs. load-line displacement



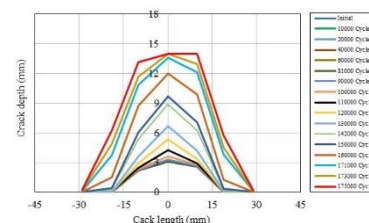
J-integral vs. crack length under monotonic loading



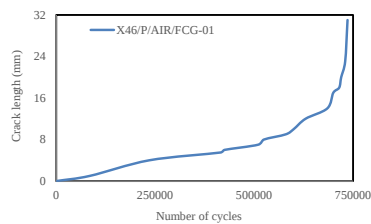
J-integral vs. crack length under cyclic loading



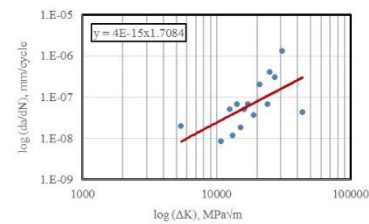
FCG test on a straight pipe under combined bending and torsion



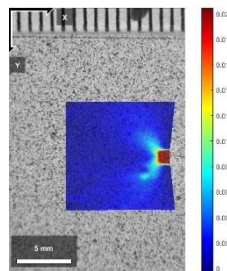
Crack profile development curve under combined bending and torsion



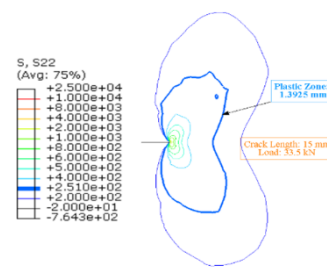
**Crack growth vs. no. of cycles for
API 5L X46 grade steel**



**Fatigue crack growth rate curve for
API 5L X46 grade steel**



**Strain field ahead of crack tip
obtained using DIC**



**Plastic zone size at a crack length of
15 mm due to overload**

Future Programme:

- Evaluation of fracture parameters under thermo-mechanical loading of piping components
- Evaluation of equivalent stress intensity factor for straight pipes with circumferential surface notch subjected to combined bending and torsion
- Numerical and experimental studies on re-rounding behaviour of dented API 5L X46 grade steel pipes under internal pressure
- Development of J-R curves for welded pipes having circumferential crack subjected to cyclic loading under displacement control
- Development of fatigue crack propagation model accounting crack retardation effect due to overload

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