

Fatigue Assessment of Welded Pipelines in Ultra-Deep Water

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ABSTRACT

Welded oil and gas transport pipelines buried in Ultra Deep water (1500m and beyond) experience more stress and display a lower fatigue life span when compared to unwelded pipelines. This is due to the inherent weakness of weld joint and/or the presence of defects therein. These defects may look negligible, but they contribute largely to the stress concentration that exists at these joints, especially when they are joints of dissimilar pipe radius (Lotsberg, 2009). These pipelines, if left unchecked may lead to leakage of transported petroleum product into the surrounding water. This type of pollution can be irreversible and expensive to manage, it can also lead to the death of organisms habiting the immediate polluted surrounding.

Two 7.1mm thick pipes of 7 inches (177.8 mm) and 8 inches (203.2 mm) outer radius were modelled as welded together. The pipeline was simulated in COMSOL Multiphysics® to experience Ultra Deepwater boundary condition at 2000 m depth such as external hydrostatic pressure, axial force and internal flow pressure which are acting on it simultaneously. The material properties were selected to represent that of a X60 steel pipe, which are used for Ultra Deepwater environments. The fatigue of the welded pipe was evaluated using the Smith-Watson-Topper model (SWT model) for pipeline models with 1.7mm, 4.7mm lack of penetration defect depth (case 1, 2) and increased axial force on 1.7mm defect depth (case 3). The size and material properties of the pipeline models were kept constant for all cases.

The result showed similar deformation patterns across all cases with slight variance in degree but a significant difference in fatigue life between case 1 which is referred to as the initial condition and cases 2 and 3. The number of cycles to failure decreasing from 109628 cycles at initial conditions (case 1) to 3551.8 cycles when the size of defect is increased (case 2) and 3357.9 cycles when axial force was increased (case 3). The result also showed the fatigue of the pipeline models generating from the defect as it gradually spreads to the smaller diameter pipe

The results showed the influence of the defect size and load magnitude on the fatigue life of the pipeline section. This makes the fatigue life of the welded joint important to evaluate in order to ascertain a safe operating condition of oil and gas transport pipelines in Ultra Deep water, and to prevent avoidable catastrophic pollution of surrounding water bodies. The welded joints are to undergo intensive welding and scheduled inspection to prevent leakage or burst. This will help to prevent expensive replacement of pipeline and determine a maintenance approach to extend the life of the pipeline

References

- Lotsberg, I., 2009. Stress concentrations due to misalignment at butt welds in plated structures and at girth welds in tubulars. *International Journal of Fatigue*, 31(8-9), pp. 1337-1345.

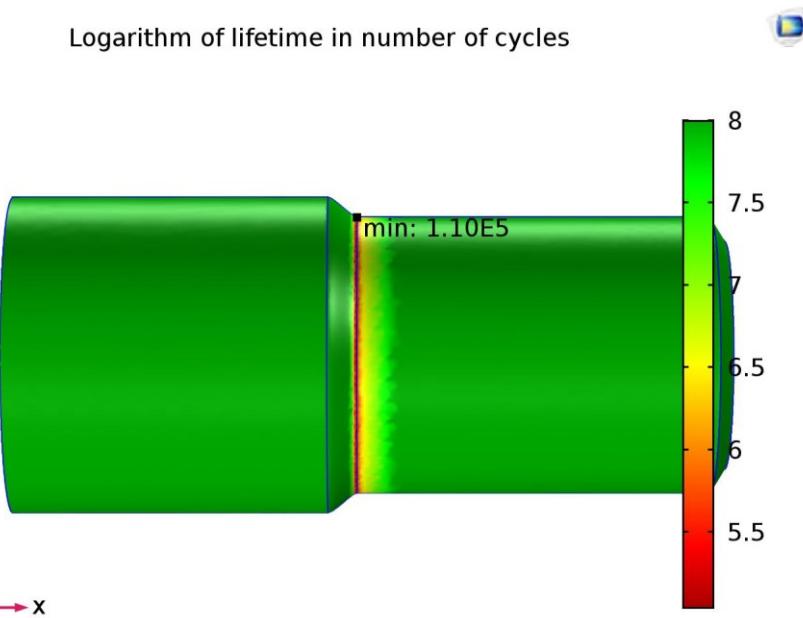


Figure 1: Fatigue life of 1.7mm lack of penetration defect depth

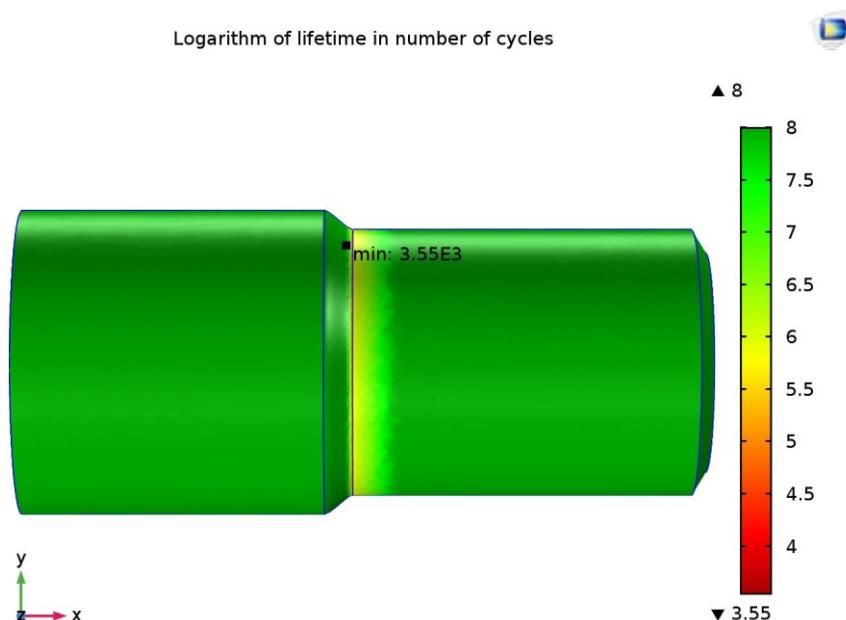


Figure 2: Fatigue life of 4.7mm lack of penetration defect depth

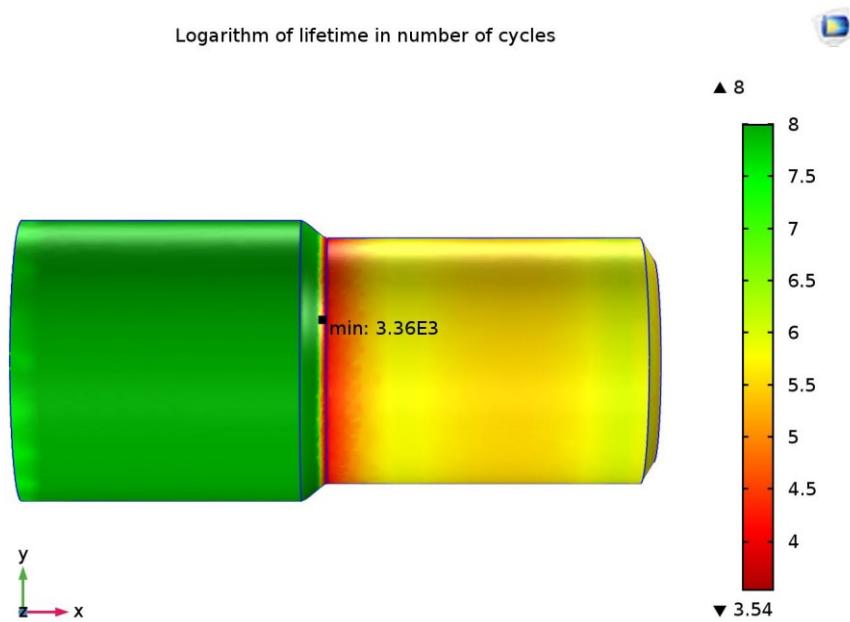


Figure 3: Fatigue life of 1.7mm lack of penetration defect depth with increased axial force