Fatigue behaviour of corrosion pits in X65 steel pipelines

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The purpose of this research was to find out the characteristics of fatigue cracks inside steel pipelines, using x-rays and replicating sea floor conditions. This is important as cracks in underwater pipes lead to oil and gas leaks, with devastating effects to wildlife and energy insecurity to humans. The research done means we will more easily know when a pipe needs to be replaced due to corrosion pits, therefore saving expense and environmental consequences.

Method:

Create a pit in the sample using a VetraScan electrochemical instrument

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Add sample to the chamber and then fill with the H_2S gas

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Apply a stress to the sample whilst rotating the chamber and taking x-ray images

There are other methods that can be used, however this method was chosen as H_2S is a toxic gas and needs to be handled in a sealed environment.

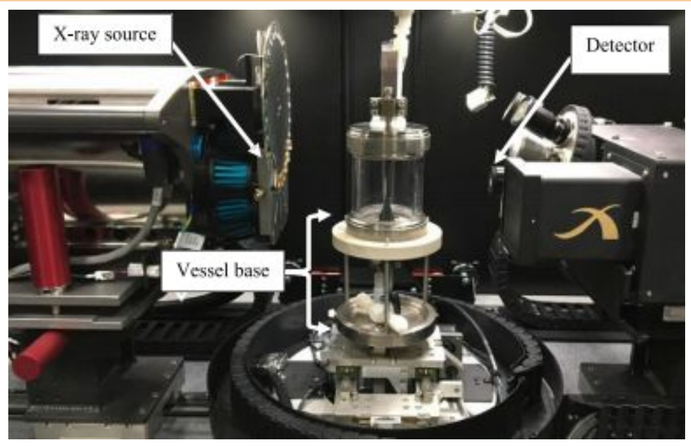

Figure 3 Test vessel inside X-ray scanner

Results:

- In figure 1 the initial crack started in the corrosion pit and spread across the fatigue crack growth zone, perpendicular to the plane where stress was applied.
- Cracks extended to a degree that a brittle fracture could take place within the fast fracture zone, culminating with crack propagation at a fast rate.

- Figure 2 shows ratchet marks and the origin of the crack when under stress. There are a multitude of crack nucleation sites around the pit. Other SEM images also show this pattern of damage.

Other SEM images show that cracks can appear close to the centre of the pit which are autonomous to the first crack, albeit these cracks did not contribute to the overall fatigue crack. Farad (2021)

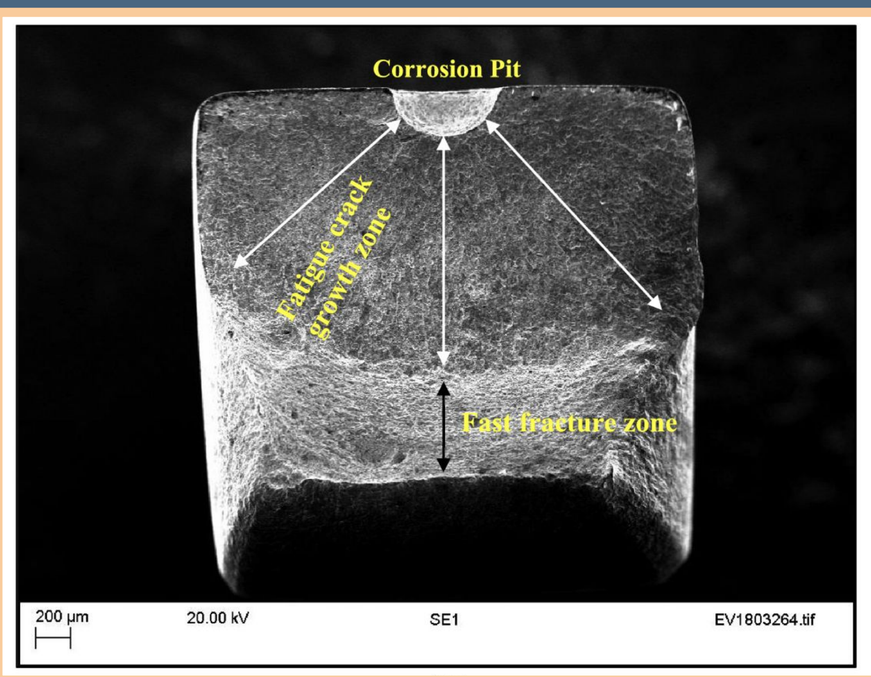

Figure 1 SEM image of an ordinary fractured specimen, experiment on in the sour environment.

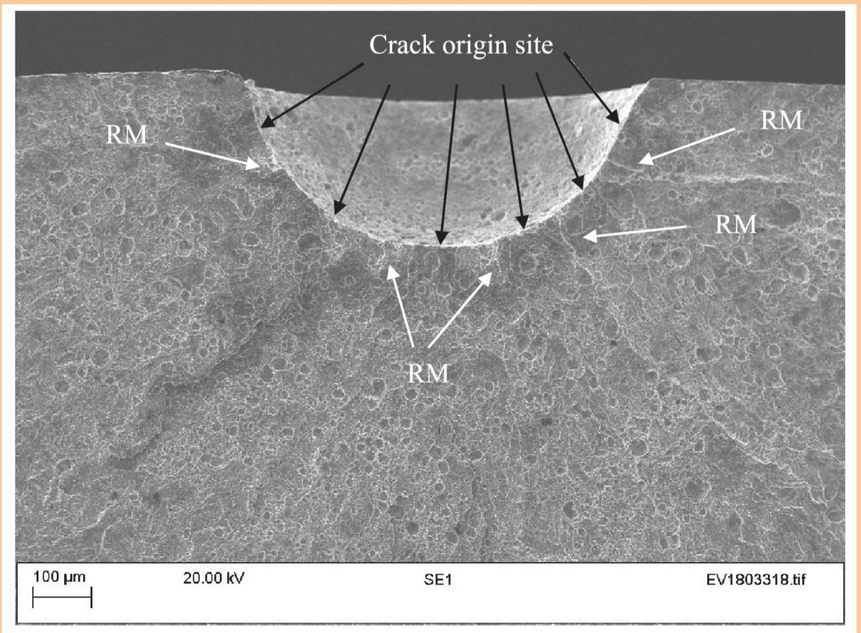

Figure 2 SEM image demonstrating ratchet marks and crack origins on a specimen with an applied stress amplitude of 185 MPa.

Discussion:

This research has identified that because the minimum local stress does not change considerably with different pit geometries after material yielding, the study of critical pit form can be based on the strain and location of strain localisation from which fatigue cracks may initiate. When the pit depth is increased the maximum strain localisation occurs near the pit bottom. In this experiment the maximum strain localisation indicates the likely locations for crack initiation. Farad (2017)

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