Fatigue Life Comparison of High Strength Steels and Conventional Steels

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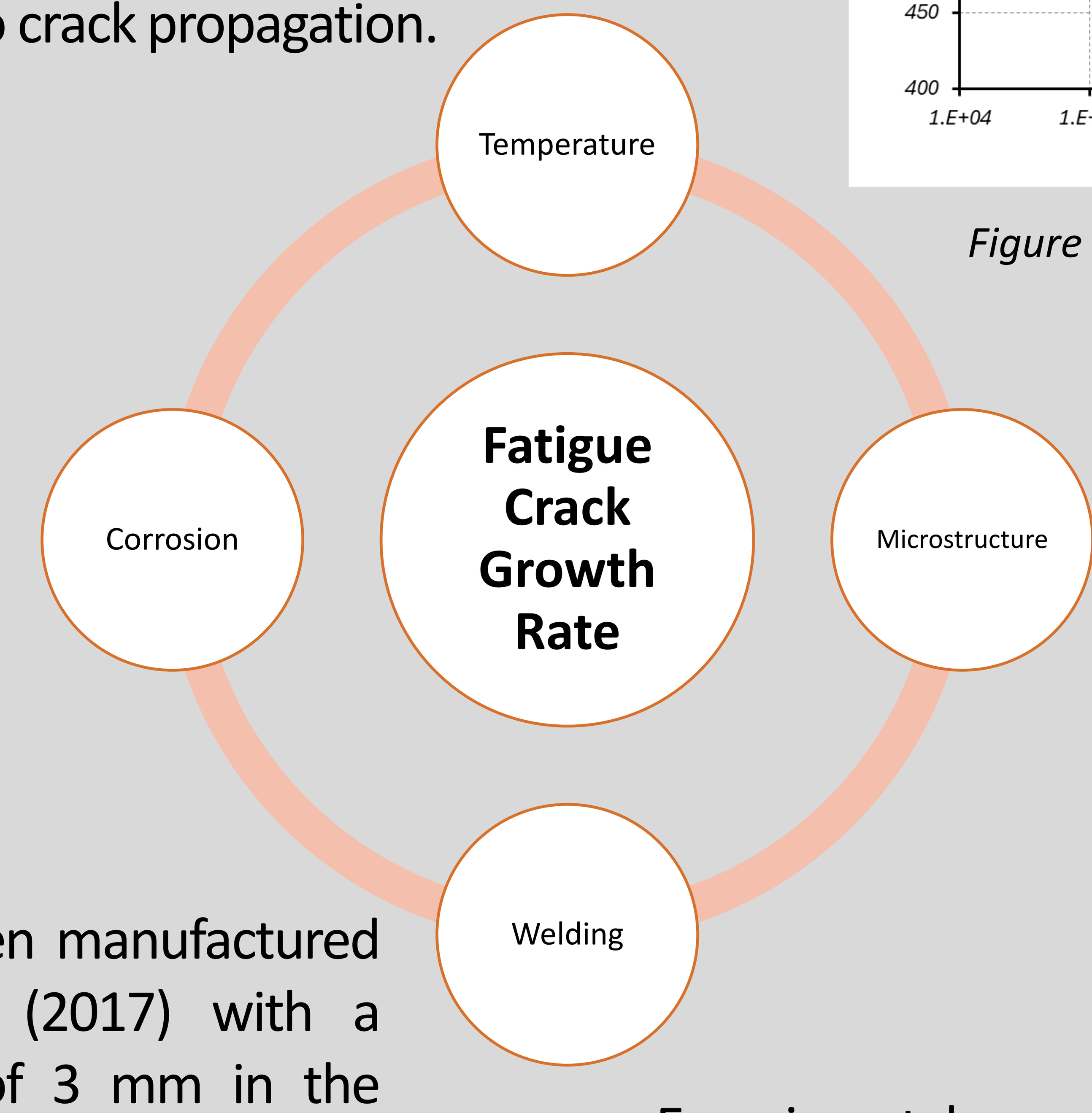
Introduction

The application of High Strength Steels (HSS) [S690, S700, S960] that has higher yield strength than the conventional steels (CSS) [S275, S355] has increased over the years to achieve lighter structures with a focus on sustainability.

Aims & Objectives

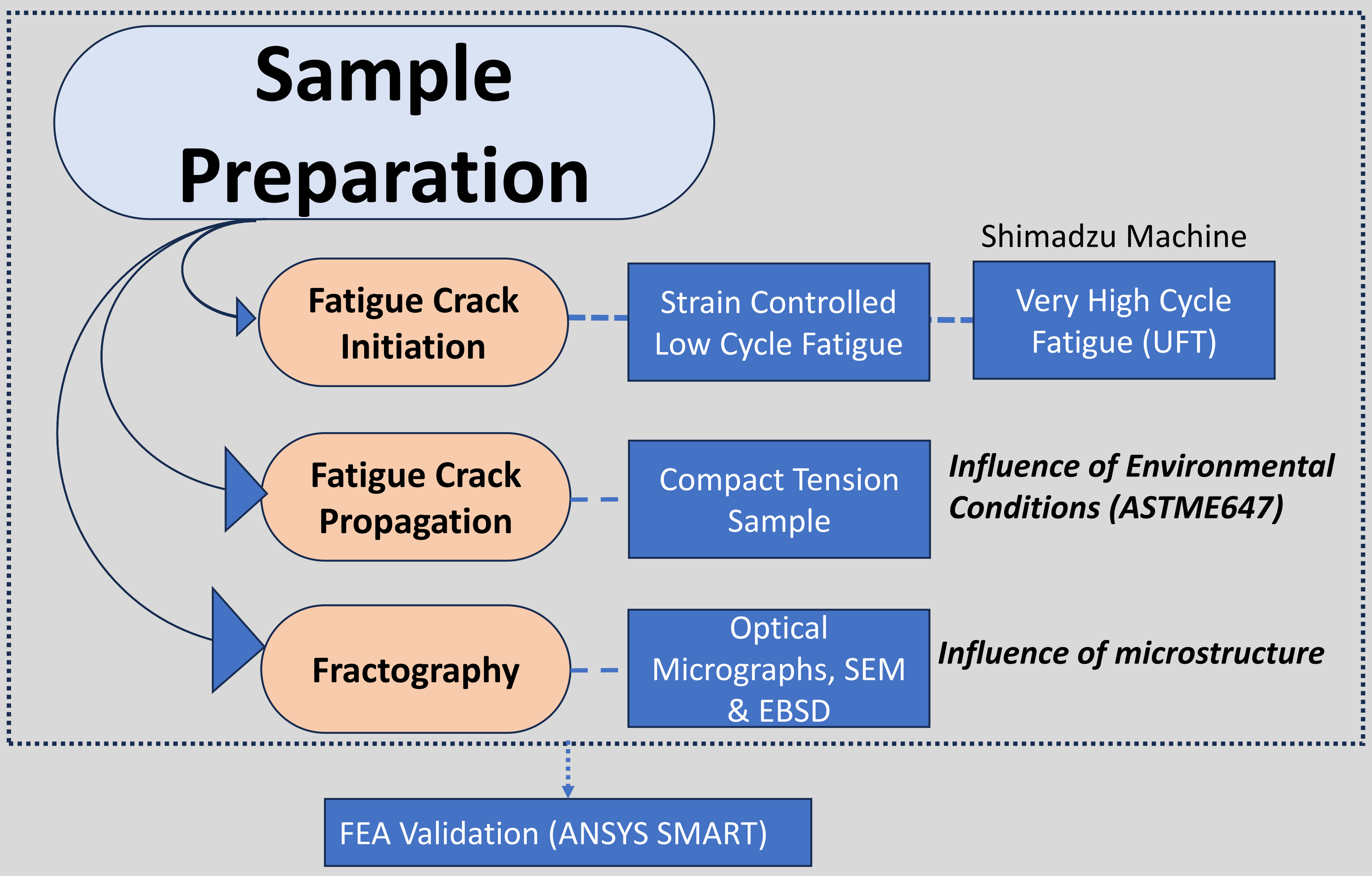
This project aims to explore the total fatigue life different grades of HSS and CSS with the effect of environmental conditions. It is assumed that HSS offers better crack initiation fatigue resistance and CSS resistance to crack propagation.



Methodology

Ultrasonic samples geometry has been manufactured following the standard WES 1112 (2017) with a minimum recommended diameter of 3 mm in the gauge location. It is designed to resonate at 20 kHz and provide efficient air cooling within the allowable range of horn end displacements.

Crack propagation test is carried on the Instron 8801 servo - hydraulic machine with 100kN load capacity. The setup is according to ASTM E647- standard and it is Mode – I loading condition.



Visual Crack Monitoring setup to track the crack growth technique on Front and Back Face as shown in Figure 1.

da/dN vs ΔK and the Paris law constants ***m*** & ***C*** are estimated with a logarithmic regression analysis shown in table.

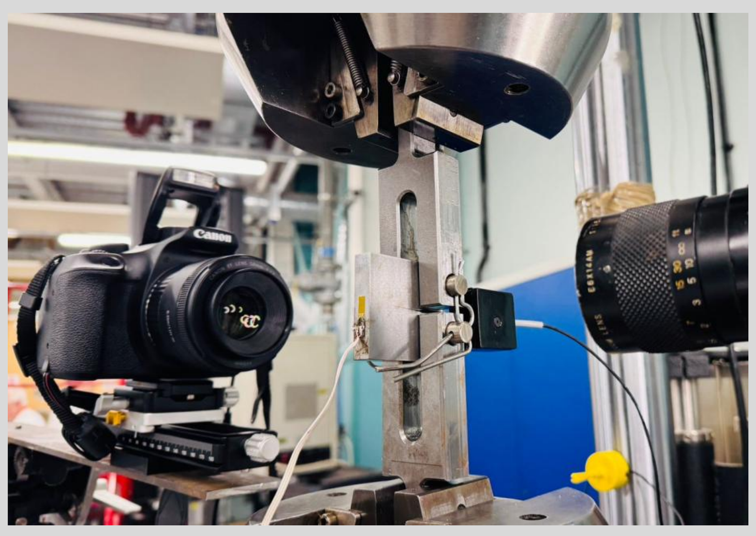
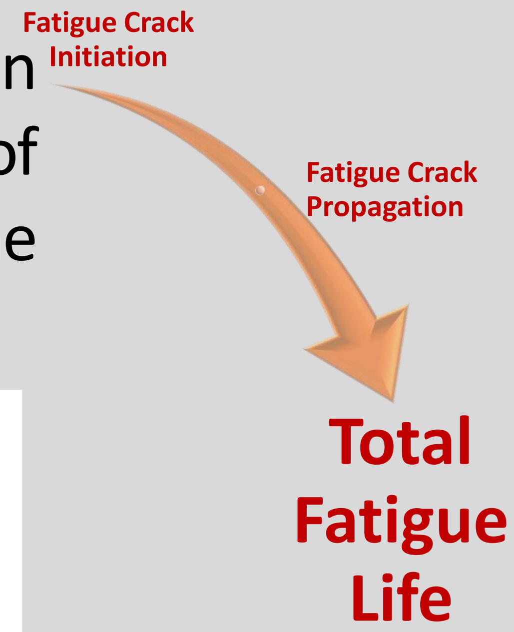


Figure 1. Visual Crack Monitoring Setup

Results

SN curve produced at 20kHz are presented in Figure 2.UFT curve exhibits a large amount of scatter for the tested grades. Scatter in the fatigue life need to be investigated.



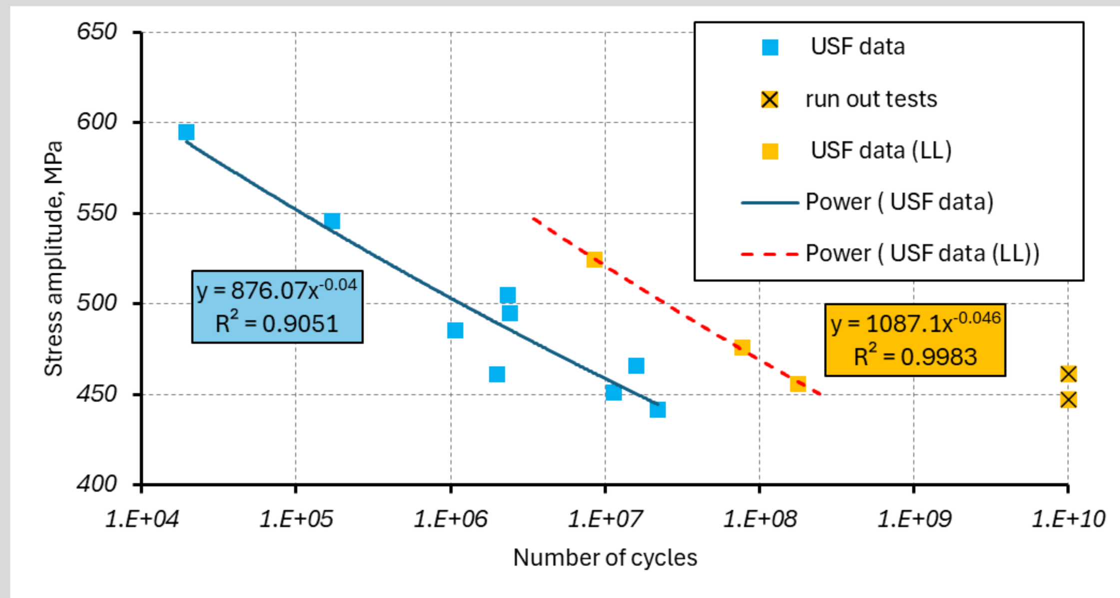


Figure 2: SN curve at 20 kHz for HSS.

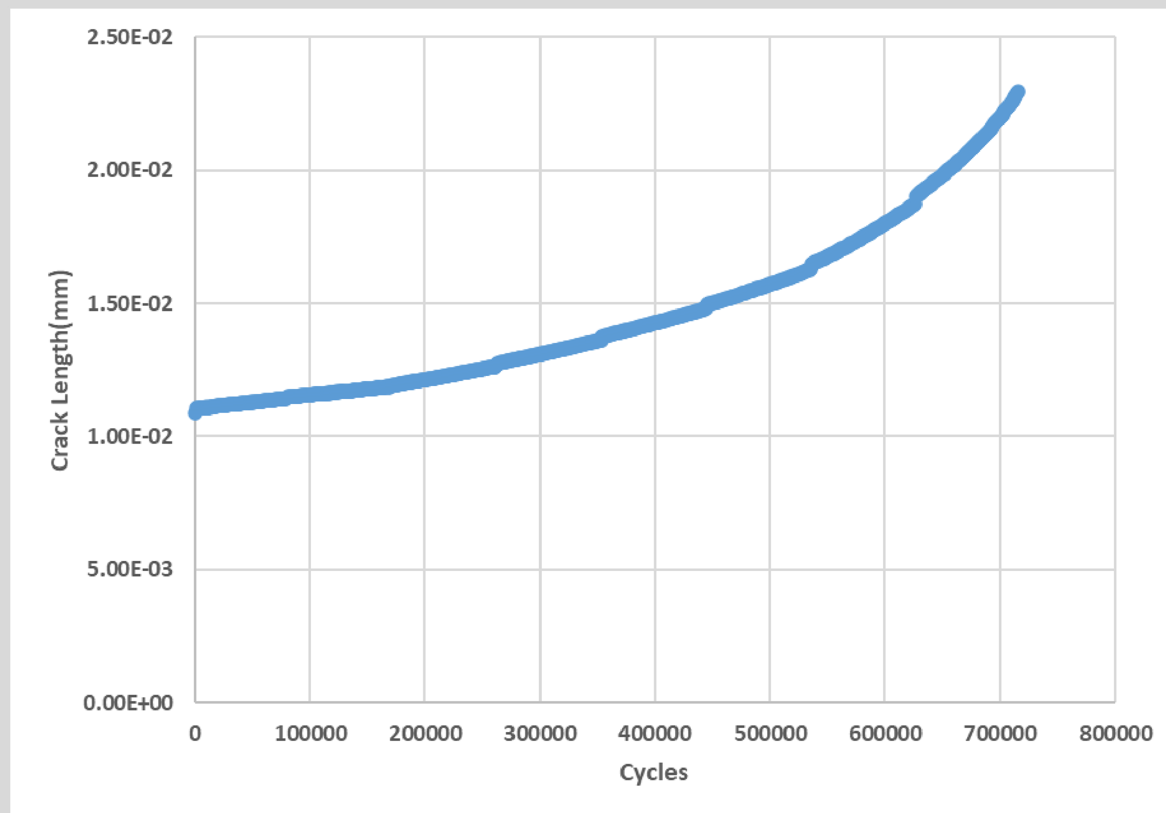


Figure 3: Cycles vs Crack length for HSS.

Experimental crack mouth opening displacement (CMOD) results are post processed to obtain crack length vs cycles. Tested at 5Hz frequency at stress ratio 0.

m	C
2.9	**4.95E-13**

Future Work

- Determine fatigue crack propagation rates in corrosive and sub-zero temperatures and validate numerical results.
- Compare the crack propagation rates steel grades under the influence of welding.
- Study about the microstructure influence on fatigue crack growth.
- Apply the experimental results on finite element numerical models of components & optimize application.

1 ***Different Environment***

Figure 3: Pre-Corroded

2 ***Fractography***

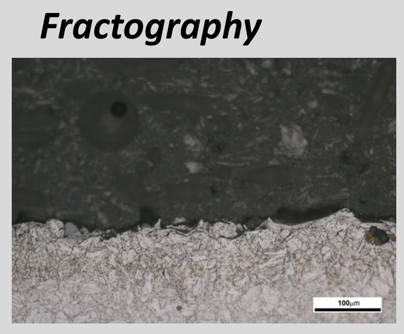


Figure 4: Microstructure

3 ***Numerical Validation***

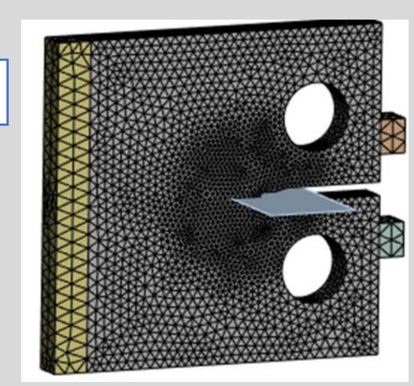


Figure 5: Meshed geometry

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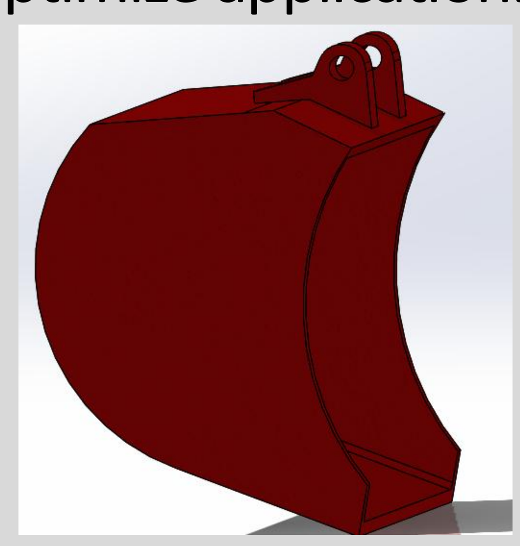

Figure 6: Excavator Bucket

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NMIS National Manufacturing Institute Scotland

Acknowledgements
The authors would like to acknowledge the support for this study (23/1/ESCO/AM&D/1072), which was provided by the Weir Group PLC (WARC2011-SAA1, 2011 via its establishment of the Weir Advanced Research Centre (WARC) at the University of Strathclyde.