ESTABLISHING THE PRINCIPLES OF COMPOSITIONAL DESIGN FOR LONG LIFE RAIL STEELS

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INTRODUCTION

Since the 1950's the rail industry has been constantly searching for improvements to existing track infrastructure, due to a trend of increasing demand on rail networks to support higher axle loads, increased speeds, and a higher amount of railway traffic (Shebani & Iwnicki, 2016). These improvements seek to lower the railway systems whole-life costs. Creating improvements is a complex matter, as there is no 'one size fits all' approach to many of the unique circumstances in the rail industry (Bevan, Jaiswal, Smith , & Cabral, 2018). For wheels and rails, many variables must be considered to find the optimal material, including, but not limited to, loading conditions and contact patch dynamics, material properties and metallurgy, as well as the economic implications and civil engineering aspects of rail infrastructure (Jaiswal J. , 2003).

AIM

This research aims to increase the understanding into which metallurgical properties are beneficial in rail steels for resisting damage mechanisms commonly experienced on track as this a neglected area of research. A greater understanding of the reaction of different steel microstructures to rolling contact fatigue (RCF), wear and cyclical loading will also be explored to aid future optimisation of the microstructural design of rail steels for longevity and lower life cycle costs. A further ambition is to correlate cyclical loading resistance to RCF initiation and growth to support the use of cyclical tests to replicate RCF conditions.

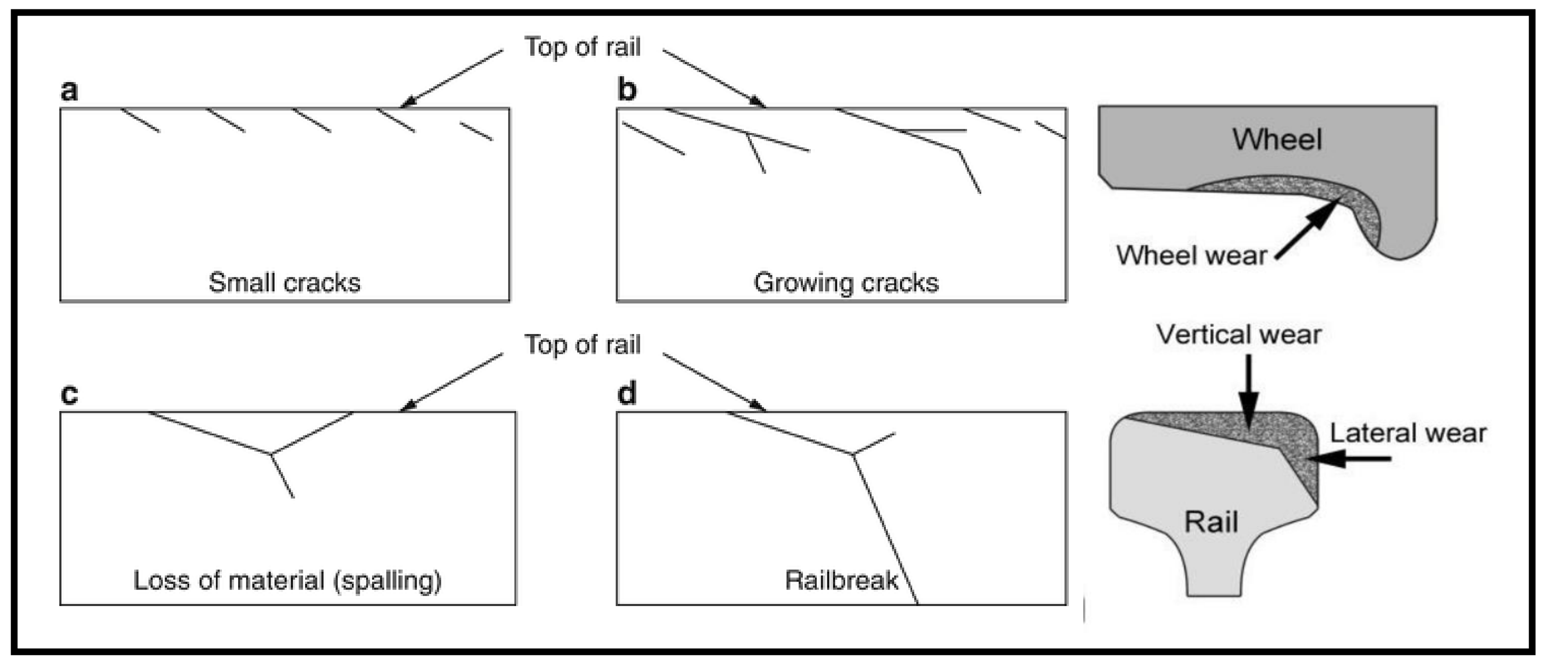

Figure 1- Illustrations of RCF and wear (Kapoor, Salehi, & Asih, 2013) & (Nanyang Technological University-Singapore, 2012)

METHOD

The Institute of Railway Research's twin disc rig is used to simulate rolling contact on a 1/3 scale. The input conditions to the rig are representative of full-scale conditions experienced on track. Wear and RCF are prevalent under different conditions and hence the rig can be set to conditions which replicate either RCF or wear.

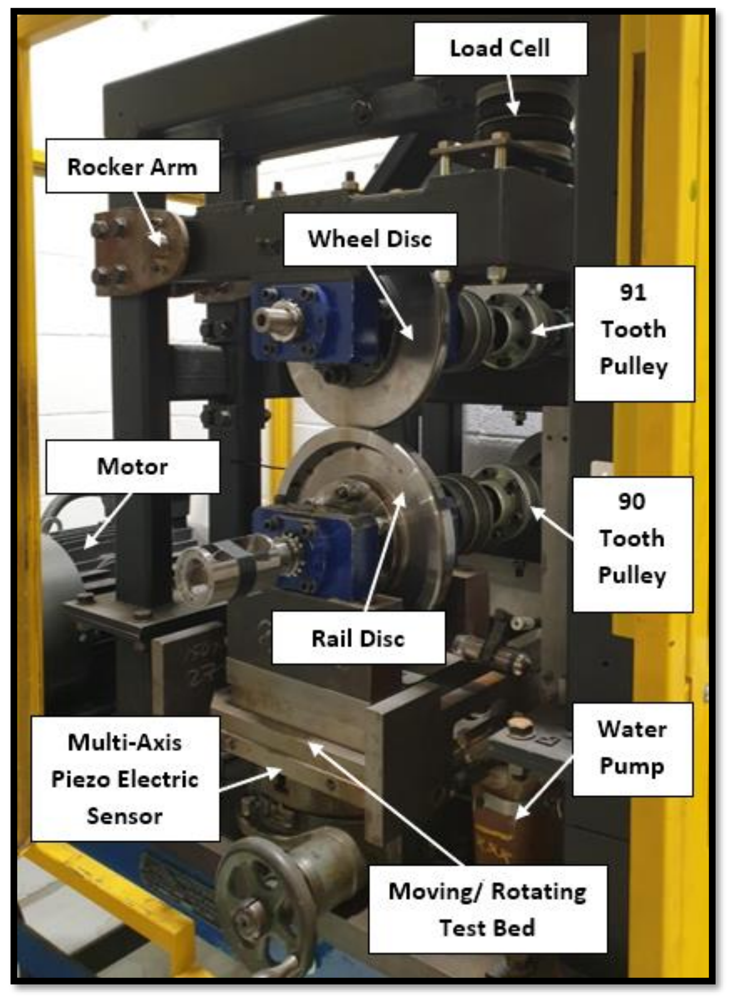

Figure 2- An annotated photograph of the Institute of Railway Research's Twin Disc Rig (Woodhead, 2021)

RESULTS

- Trailed a new RCF twin disc methodology for applying wet and dry cycles inline with real world weather patterns
- Steels showed expected differences in RCF performance
- Generated RCF cracks at expected number of cycles from literature

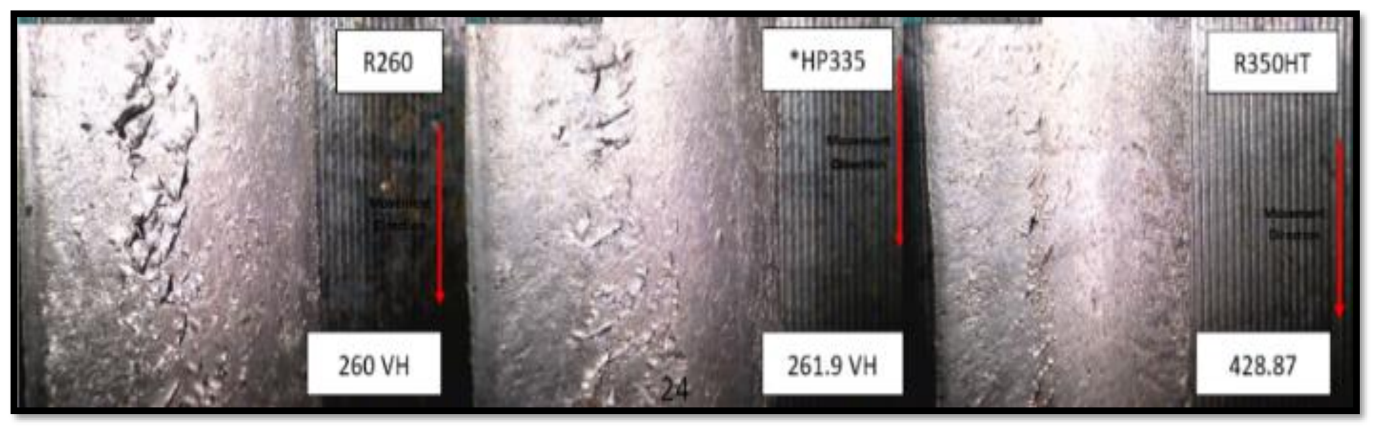

Figure 3- An annotated photograph of RCF cracks on tested samples

CONCLUSIONS & FUTURE WORK

- Testing several rail steel samples representative of the most commonly used steels on track, for example R260 the most common steel used on track.
- Testing under a vigorous test matrix which includes a wide variety of loading conditions encountered on track.
- The samples will be examined under scanning electron microscope, Xray diffraction, Xray fluorescence, microhardness and optical microscopes to characterise all the metallurgical and chemical composition properties
- The parent microstructure will be compared with the affected microstructure of each load case
- The microstructural characteristics, for example interlamellar spacing and volume fraction cementite, will be compared directly to wear and RCF unlike previous literature which always links damage mechanisms to mechanical properties.

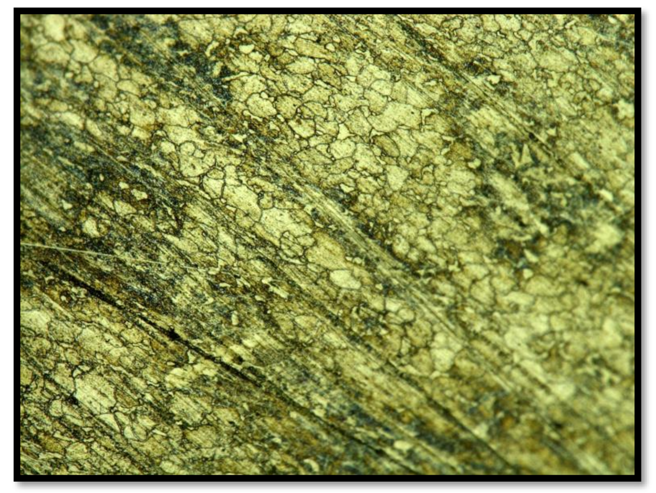

Figure 4- A 500x mag photograph of a 3% nitric acid etched rail steel surface

REFERENCES

Bevan, A., Jaiswal, J., Smith , A., & Cabral, M. O. (2018). Judicious Selection of Available Rail Steels to Reduce Life Cycle Costs. *Journal of Rail and Rapid Transit*, 29. doi:https://doi.org/10.1177/0954409718802639

Jaiswal, J. (2003). THE CONTRIBUTION OF RAIL METALLURGY TO TRACK INTEGRITY., (p. 16). Retrieved from https://trid.trb.org/view.aspx?id=749364

Kapoor, A., Salehi, I., & Asih, A. M. (2013). Rolling Contact Fatigue (RCF). (Y.-W. C. Q. Jane Wang, Ed.) *Encyclopedia of Tribology*. doi:https://doi.org/10.1007/978-0-387-92897-5_287

Shebani, A., & Iwnicki, S. (2016). The Effect of Surface Condition on Wear of a Railway Wheel and Rail. *International Journal of Mechanical and Mechatronics Engineering, 10*(9), 8.

Woodhead, D. H. (2021). Investigating the performance of rail steels. *Fields: journal of Huddersfield student research,* 7(1). doi:https://doi.org/10.5920/fields.810

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