Rolling Contact Fatigue (RCF) Analysis of a Railway Wheel

– Maysam Kiani, et al.

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BACKGROUND

Technological advancements in the railway industry have made possible longer wear lives of wheels. Simultaneously, current economical and logistical needs demand increased train speeds and load capacities. These demands result in larger contact forces acting on rails and wheels. Longer wear lives, higher speeds and larger loads have made fatigue the new main cause of railway wheel replacement and re-engineering.

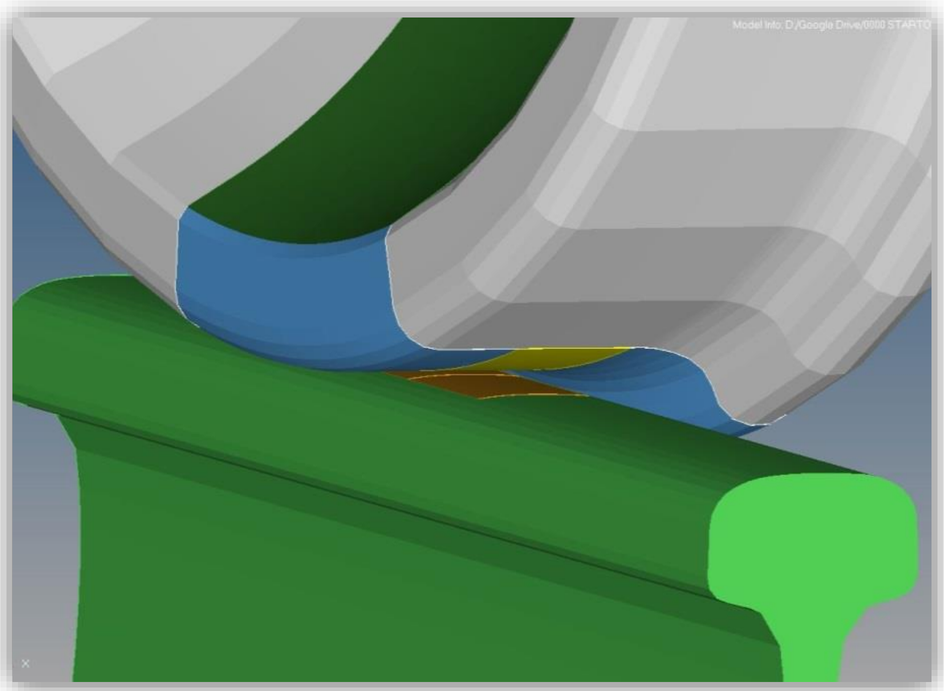
According to the Union Pacific Railroad wheel fracture database, 65% of railroad wheel failures are caused by shattered rims, a form of subsurface initiated rolling contact fatigue (RCF). This suggests a need for methods that can effectively predict the occurrence of RCF cracks. Effective predictions require computational tools and mathematical models that can accurately simulate actual material behavior and structural interactions like the contact between railway wheels and rails that takes place as the wheels roll.

* Canadian National Freight train (2014)

OBJECTIVE AND APPROACH

The objective of this project is to provide an adequate numerical assessment of the subsurface crack initiation and propagation in railway wheels.

First 3-D FE-model of defect-free wheel on rail was constructed in HyperMesh® and solved with ABAQUS® to simulate the stress/strain fields that take place at the subsurface level of the wheel.



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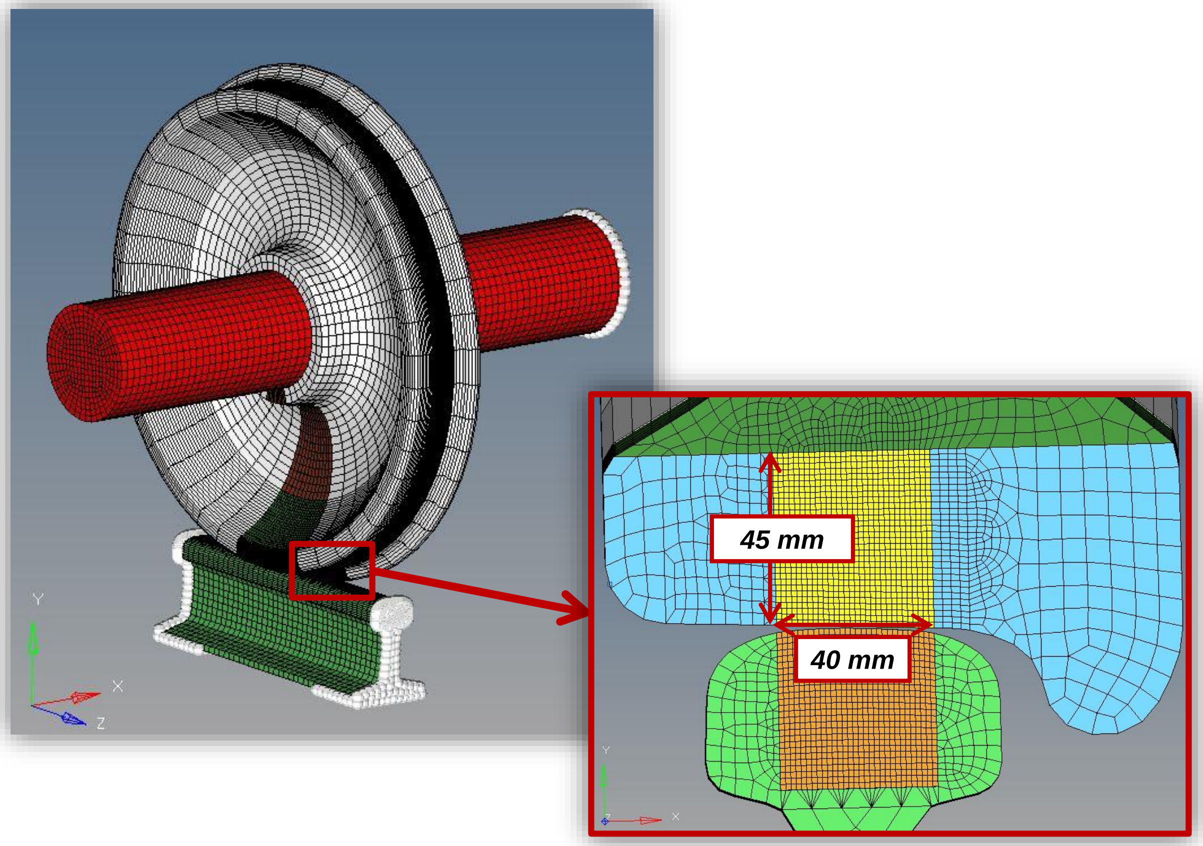
OBJECTIVE AND APPROACH

Then a penny-shaped crack added to the wheel subsurface (10 mm from the tread) to study the effect of a defect on the railway wheel fatigue life.



Finally the steady-state stress/strain response of the wheel will be the input to post-process using codes written in MatLab® to obtain improved analytical predictions of the subsurface crack initiation and propagation in the railway wheel.

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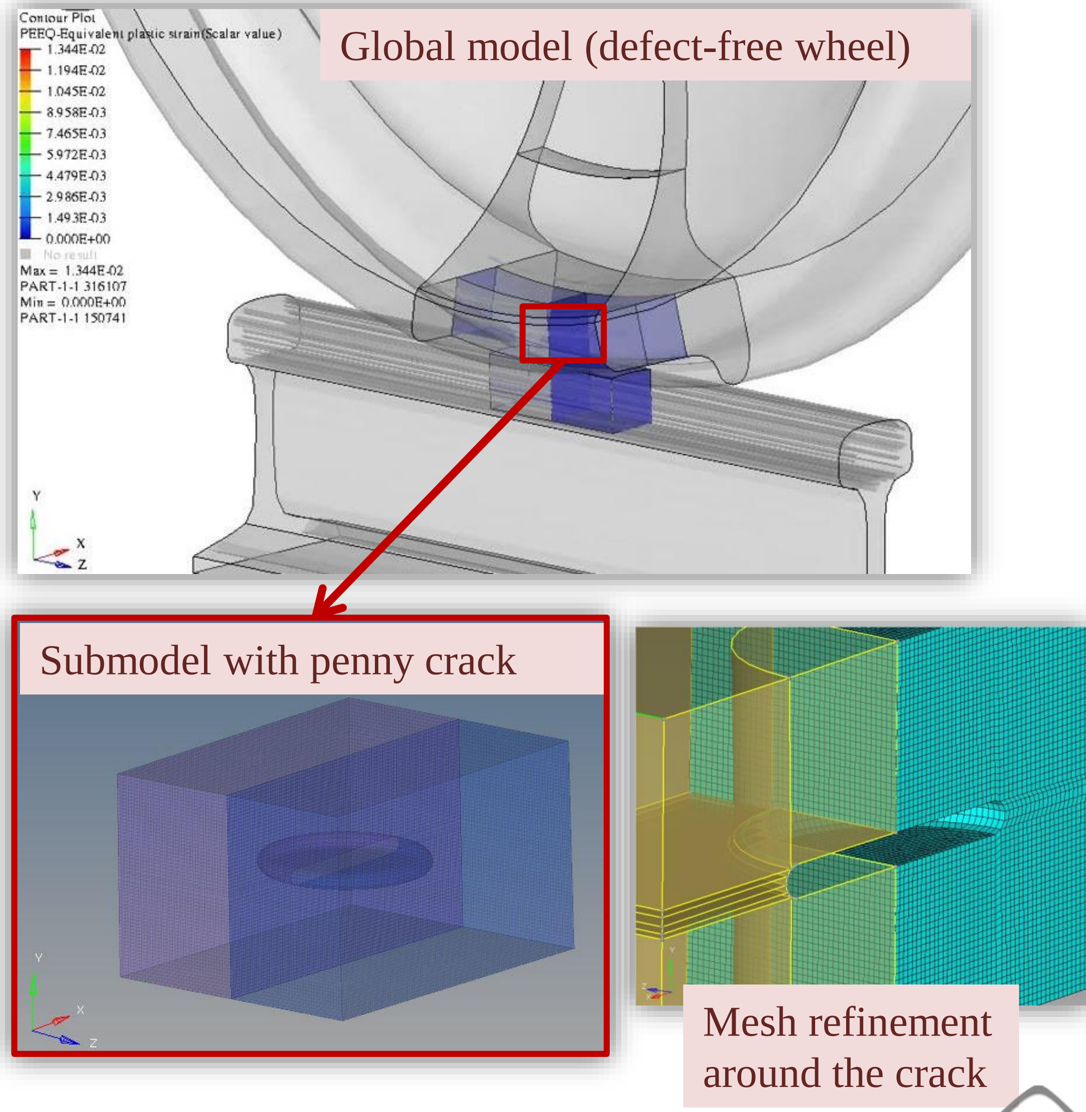
COMPUTER SIMULATION

- To achieve both computational efficiency and accuracy submodeling technique is used. Following are the model assumptions, statistics, and the employed resources:
- Analysis performed on Ada cluster of High Performance Research Computing (HPRC) of Texas A&M University.
- ABAQUS scalability test for this type of analysis is performed to decide on the optimum number of cores (3-4 cores with 20 CPUs on each node and the total run time of 48-60 hours for one cycle).
- Chaboche elastoplastic material model with isotropic and kinematic hardening is used.
- Global model and submodel comprise 300,000 and 2,000,000 elements, respectively.



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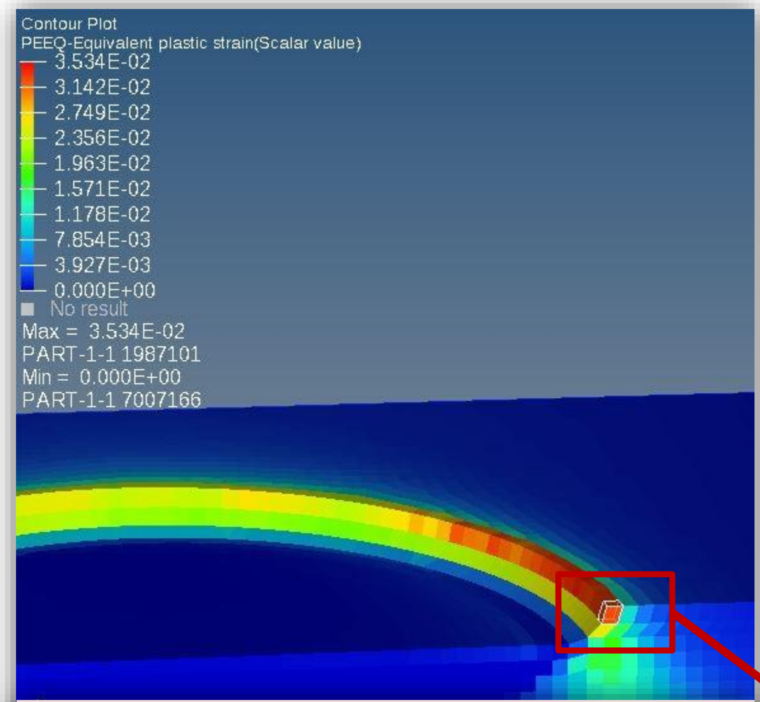
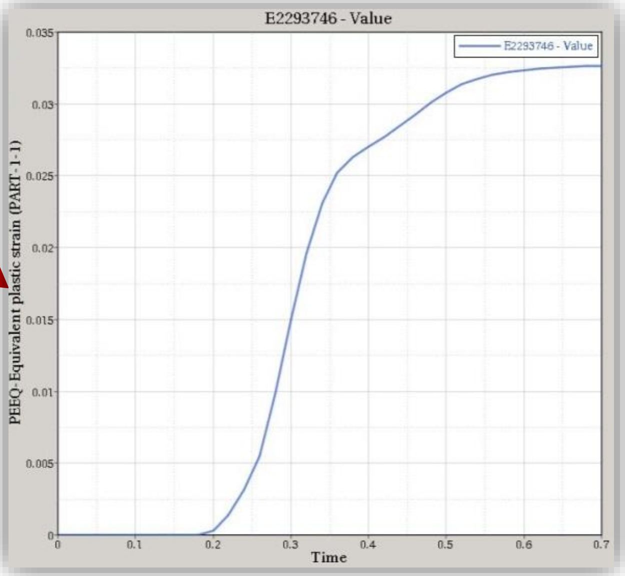
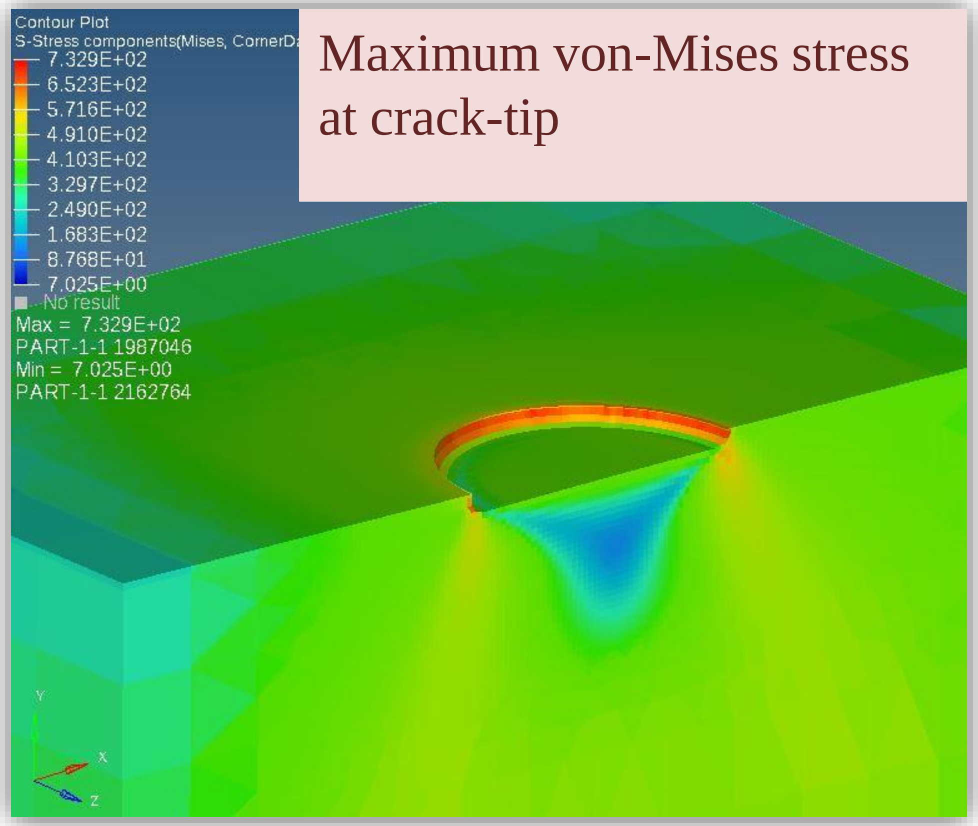
PRELIMINARY RESULTS



Equivalent plastic strain time-history at a crack-tip element





Maximum von-Mises stress at crack-tip

IMPACT ON RAILWAY COMMUNITY

- Provide railway wheels with more refined fatigue life assessment methods.
- Potential for life extension of railway wheels.
- Prevent possible derailment due to fatigue-induced subsurface cracks.

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