Modelling Rail Wear:
A Comprehensive Analysis using Archard Model and Finite Element Method

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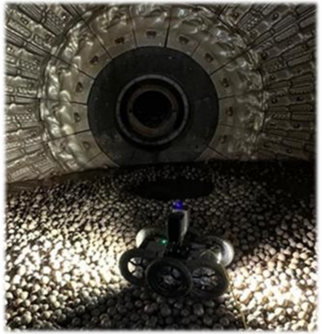

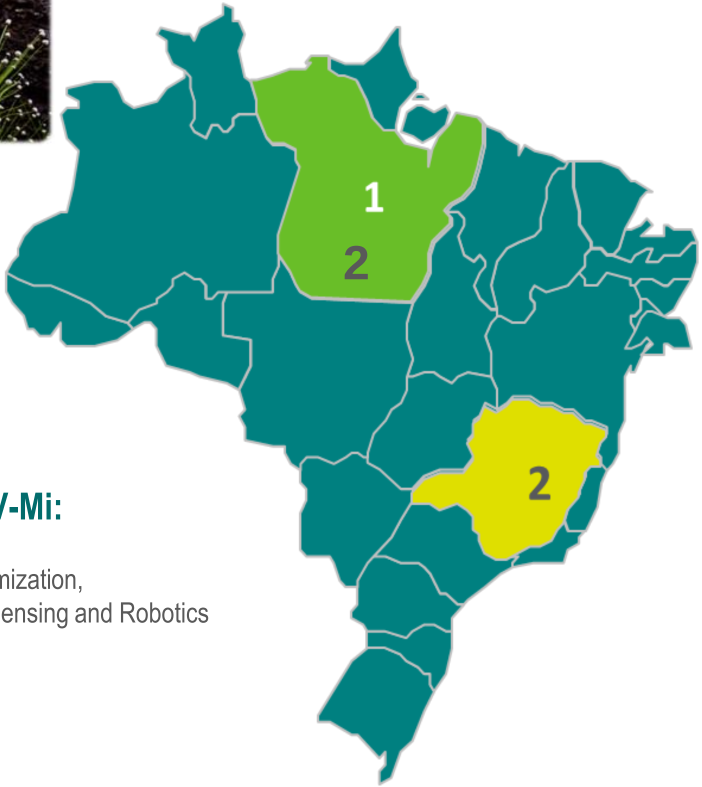

Research Areas ITV-Mi:

- Control, Instrumentation, Optimization, Mineral Processing, Remote Sensing and Robotics
- Mining
- Tribology and Shipping

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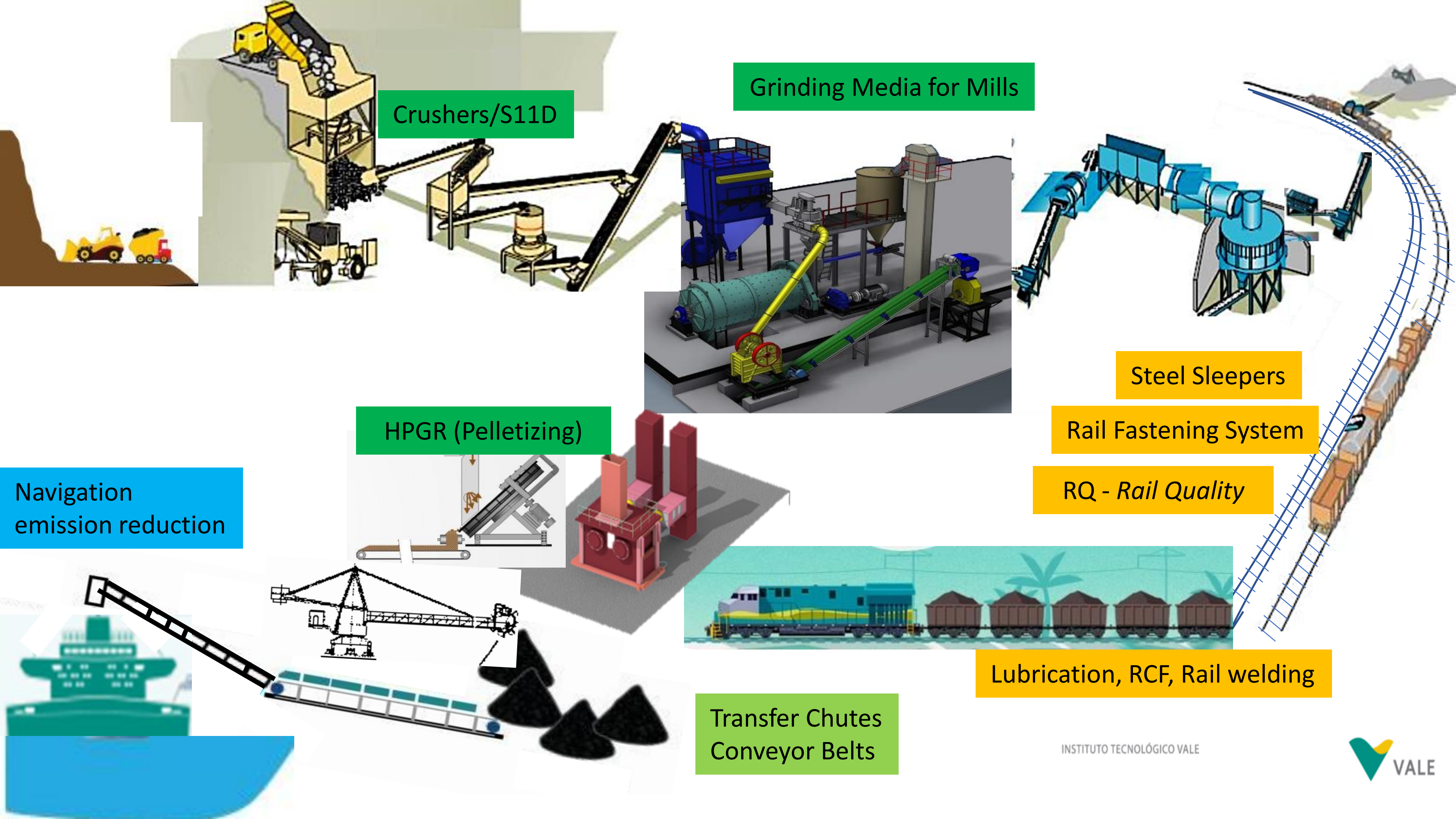
Crushers/S11D
Grinding Media for Mills
Steel Sleepers
Rail Fastening System
RQ - *Rail Quality*
HPGR (Pelletizing)
Navigation emission reduction
Lubrication, RCF, Rail welding
Transfer Chutes
Conveyor Belts
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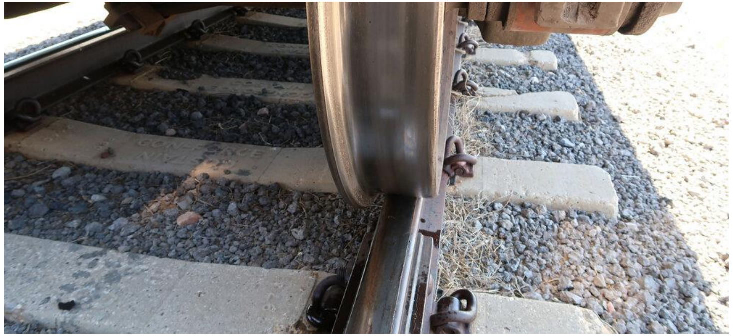
Outline

- Introduction and Objectives
- Archard Equation
- Finite Element Model
- Experiments, Calibration and Validation Procedures
- Results/Discussion
- Conclusions

Introduction and Objectives

- Rail wear is a critical issue in railway operations, affecting safety, efficiency, and maintenance costs
- Accurate prediction of rail wear can provide valuable insights for optimizing maintenance practices, prolonging the lifespan of rails, and reducing operational disruptions.
- This work presents a numerical model that aims to predict rail wear in railway operation, based on the linear Archard's wear law and finite element modeling (FEM).
- FEM Commercial programs do not calculate wear
- Resulting worn profiles was compared to experimental data
- General FEM model to predict wear in complex geometries
- Wear regime transition



Archard Wear Model

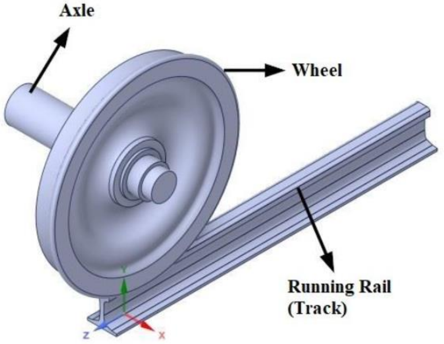
Archard's wear Equation can be used to describe sliding wear

$$V \; \alpha \; \frac{W.s}{H}$$

$$V = k.\frac{W.s}{H}$$

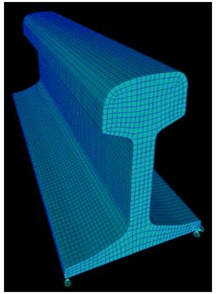
V = Volume
W = Normal load
s = Sliding Distance
H = Surface Hardness

Archard formulation applied at a local scale:

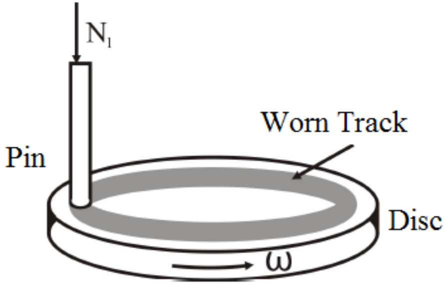


$$\frac{V}{A} = k.\frac{W.s}{H.A}$$

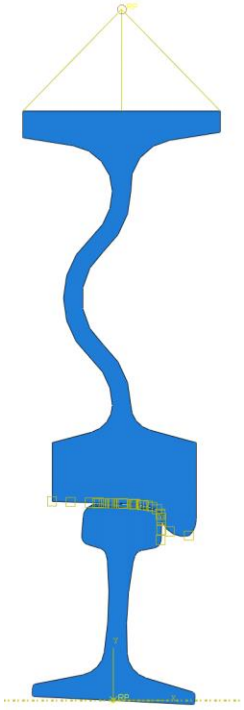
$$d\delta = k.\frac{P.ds}{H}$$

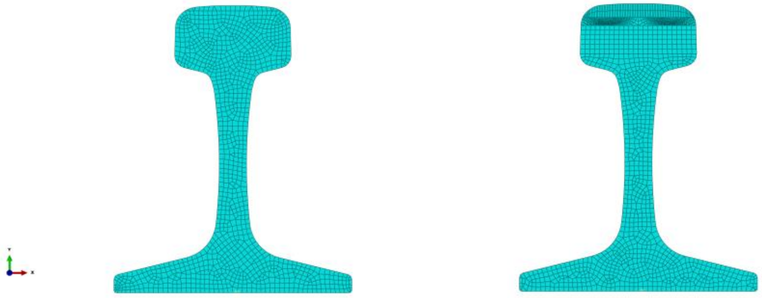


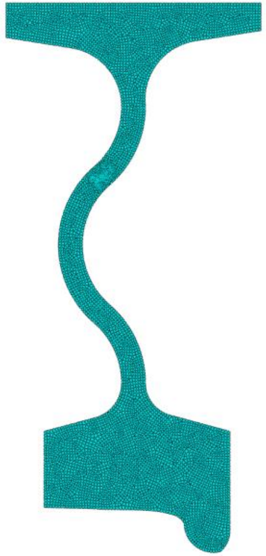
Pin on disc tests are widely used in order to evaluate the tribological performance



Finite Element Model

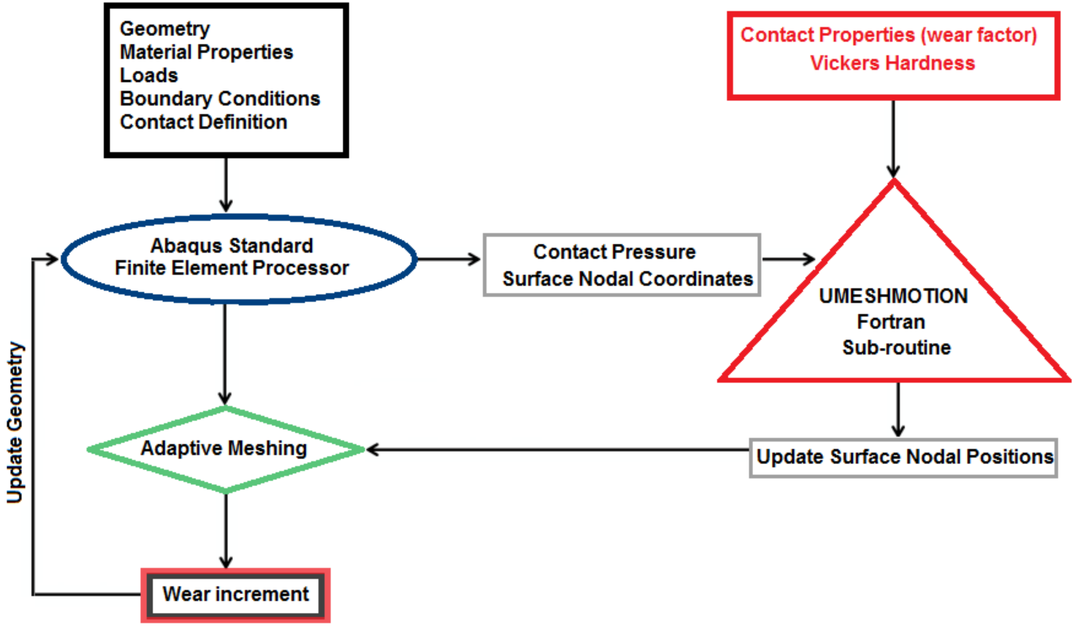






- A numerical finite element method is proposed, developed with the software Abaqus.
- The finite element analysis implemented in this work develops a numerical model based on the Archard’s equation for calculating sliding wear
- 2D geometry (TR68 rail geometry; wheel radius = 460 mm)
- Materials were considered elastoplastic (H ~ 400HV)

Finite Element Model



Bortoleto et. al, 2013.

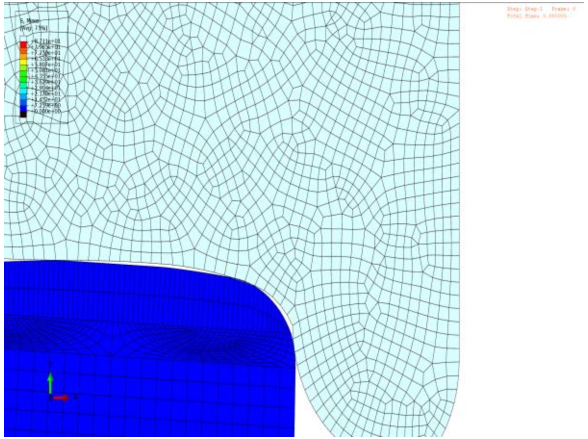
UMESHMOTION subroutine

$$dV = k\frac{dW}{H}ds$$

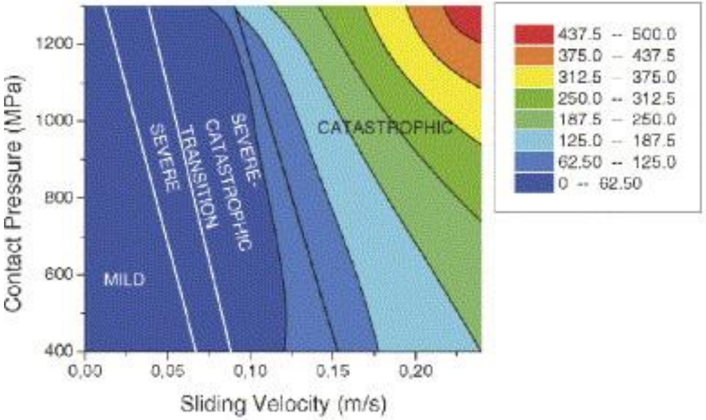
$$d\delta = \frac{dV}{dA} = k\frac{P_C}{H}ds$$

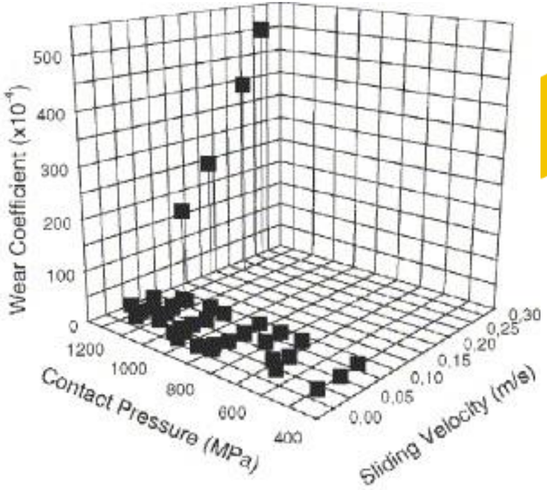
Experiments, Calibration and Validation Procedures

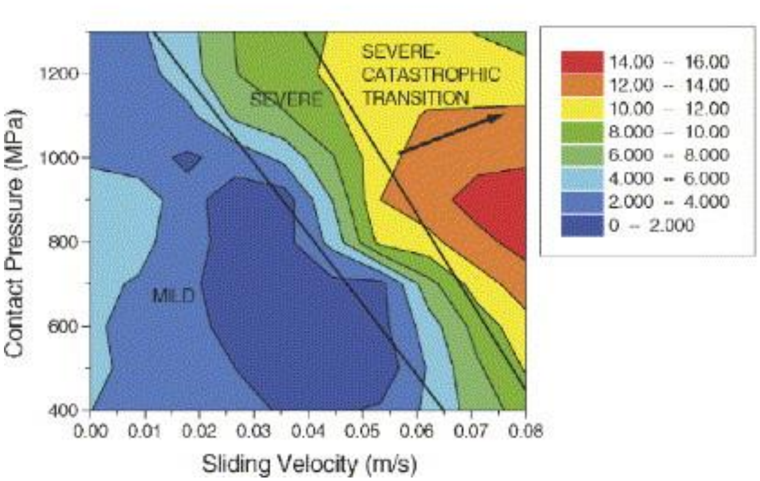
- Relationship between laboratory tests or real rail wear measurements and numerical results

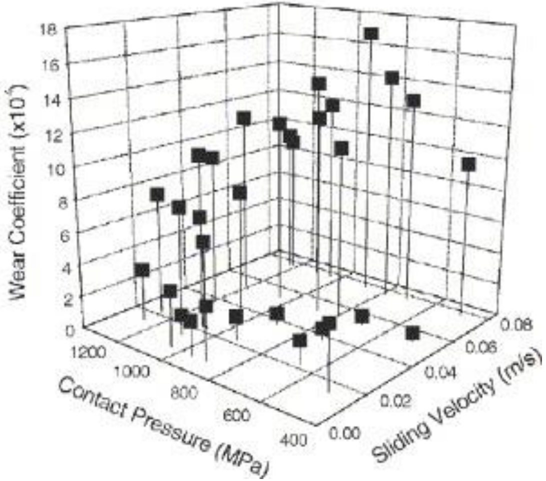


- Pin on disc tests
- Twin-disc tests
- Obtain reliable wear coefficients to use as input in FEM model



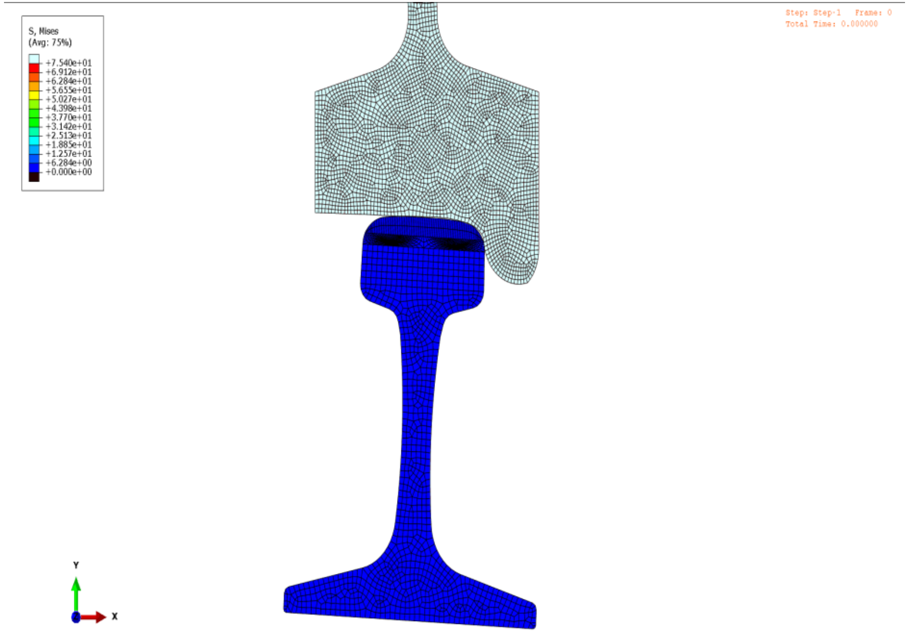






Lewis R. & Olofsson, U. Mapping rail wear regimes and transitions

Results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(Avg: 75%)
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+3.770e+01
+3.142e+01
+2.513e+01
+1.885e+01
+1.257e+01
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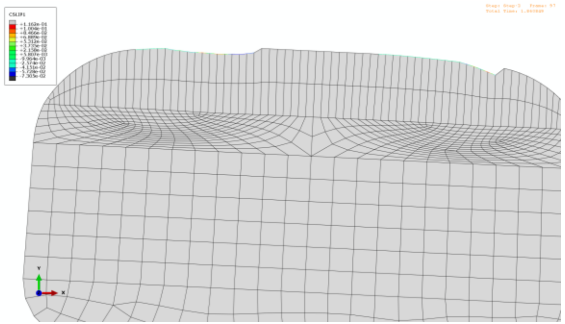
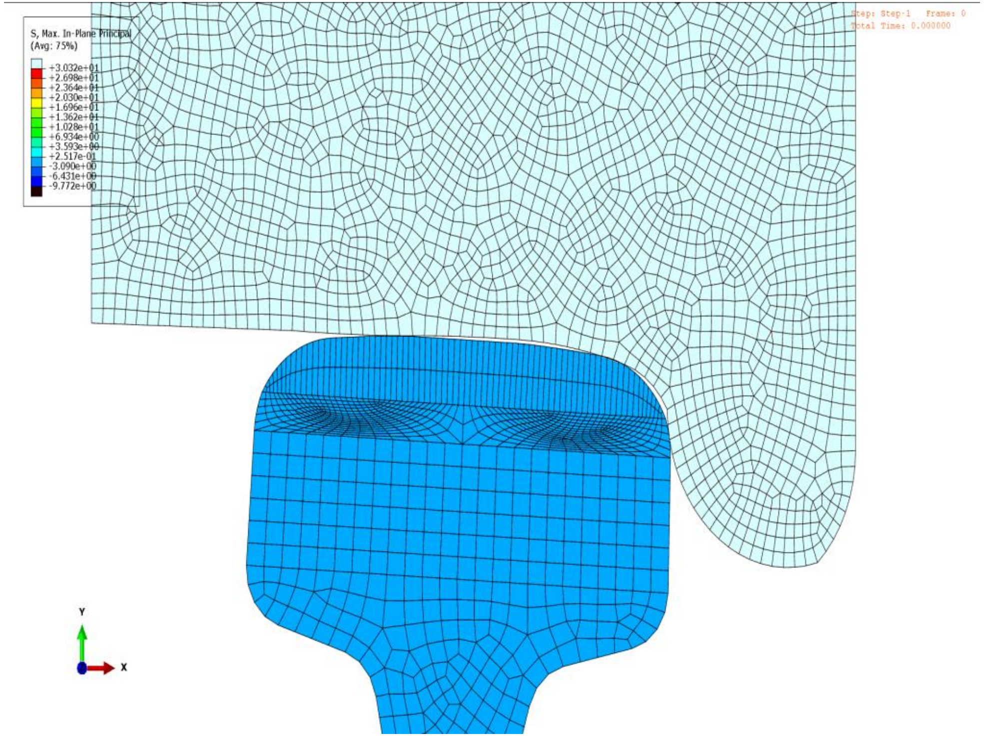
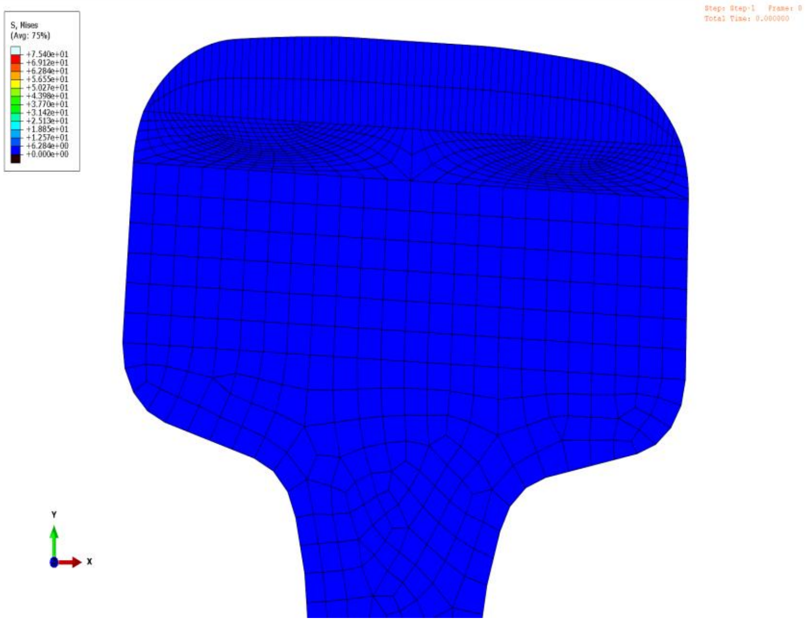


Results

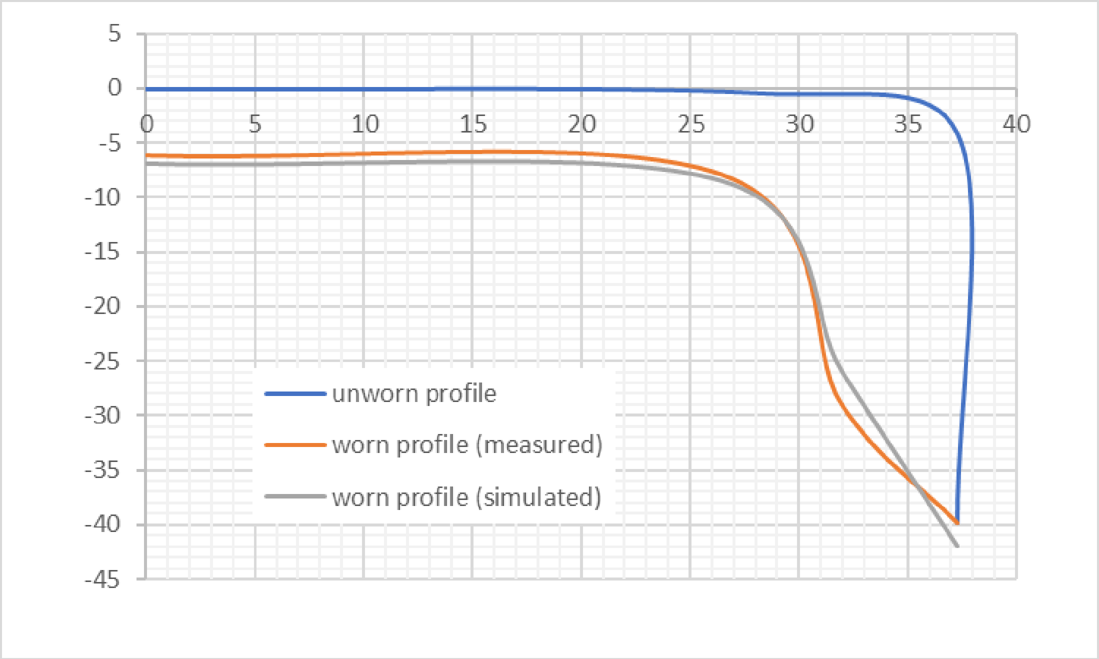


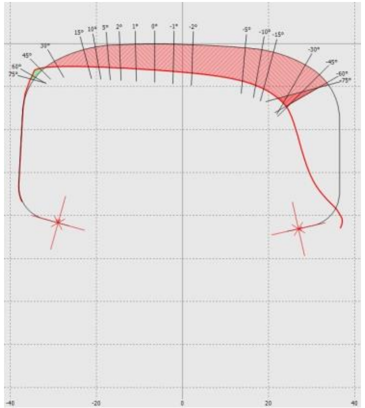
changing the points of maximum contact pressure due to geometry variation due to wear

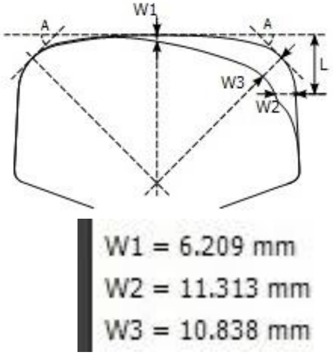


Evolution of rail profile due to wear

Results







- 300 MGT (Million gross tons) transported

- railway curve radius = 250m

Conclusions and model limitations

The model is quite dependent on the wear coefficient values

Simulated values for top of rail wear (rail crown wear) were slightly overestimated

The model is not able to reproduce material removal phenomena due to grinding process or Rolling contact fatigue.

Thank you!

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Thank you!