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Prediction of wheel profile wear and rolling contact fatigue for the Stockholm commuter train

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Overview

- Project goals
- Scope of this presentation
- Methods
- Results
- Conclusions

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Project

- The main goals of the project are:
  - To create one model for prediction of the total expected life of wheels and rails
  - Selection of reference vehicles, lines and curves for validation of the models
  - Perform/collect measurements
  - Validation of the model
  - Apply the model to investigate the influence of different parameters (wheel/rail profiles, vehicle suspension, axle load, track condition etc.)

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Scope of this presentation

- To study the behavior of two reference vehicles with respect to wear and RCF of the wheels.
  - Two wear and two RCF prediction models have been used in combination with vehicle dynamics simulations.
  - Multi-body simulations in Gensys provided the input to the wear and RCF models

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Methods

- Two reference vehicles, running on the Stockholm commuter network, have been selected

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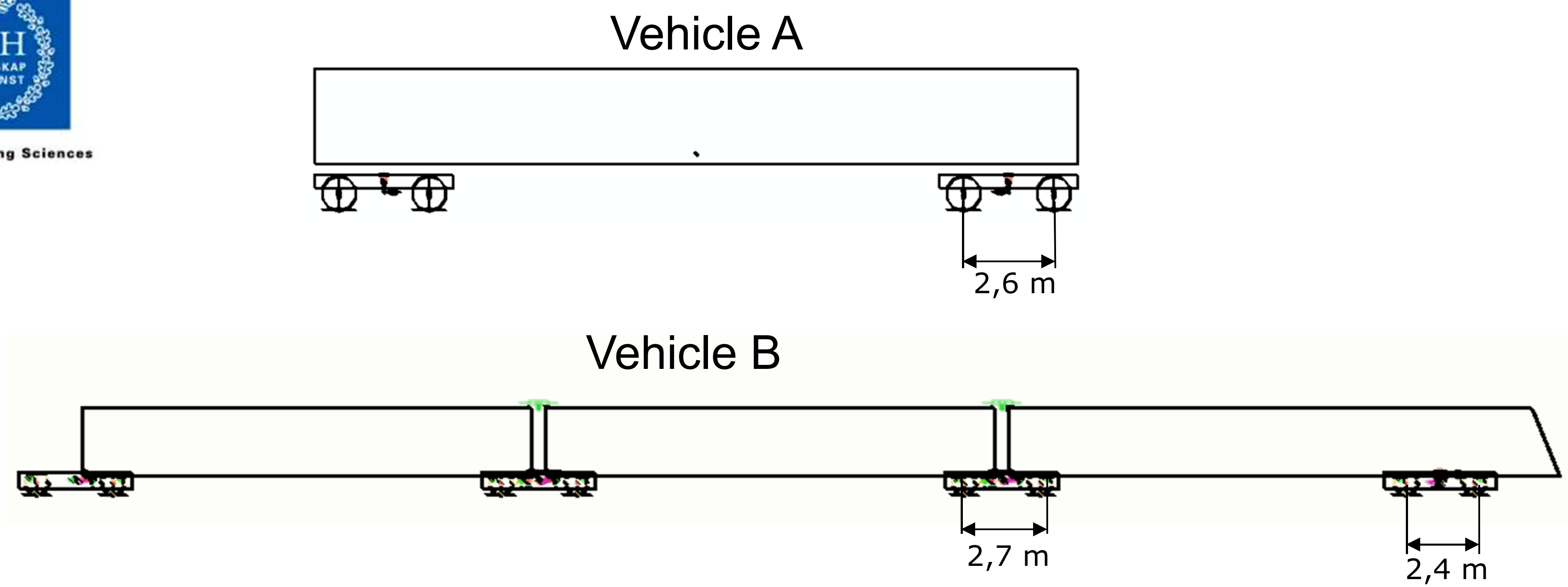

Methods – RCF models

- Two RCF initiation prediction models have been studied and compared:
  - 1) based on the shear stress (SI-model)
  - 2) based on the energy dissipation (DI-model)

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Methods – RCF models

- Surface initiated RCF index (SI) of the form:

$$SI = (\tau - k) > 0$$

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$$FI = \frac{(\tau - k)}{p} > 0$$

Shakedown map

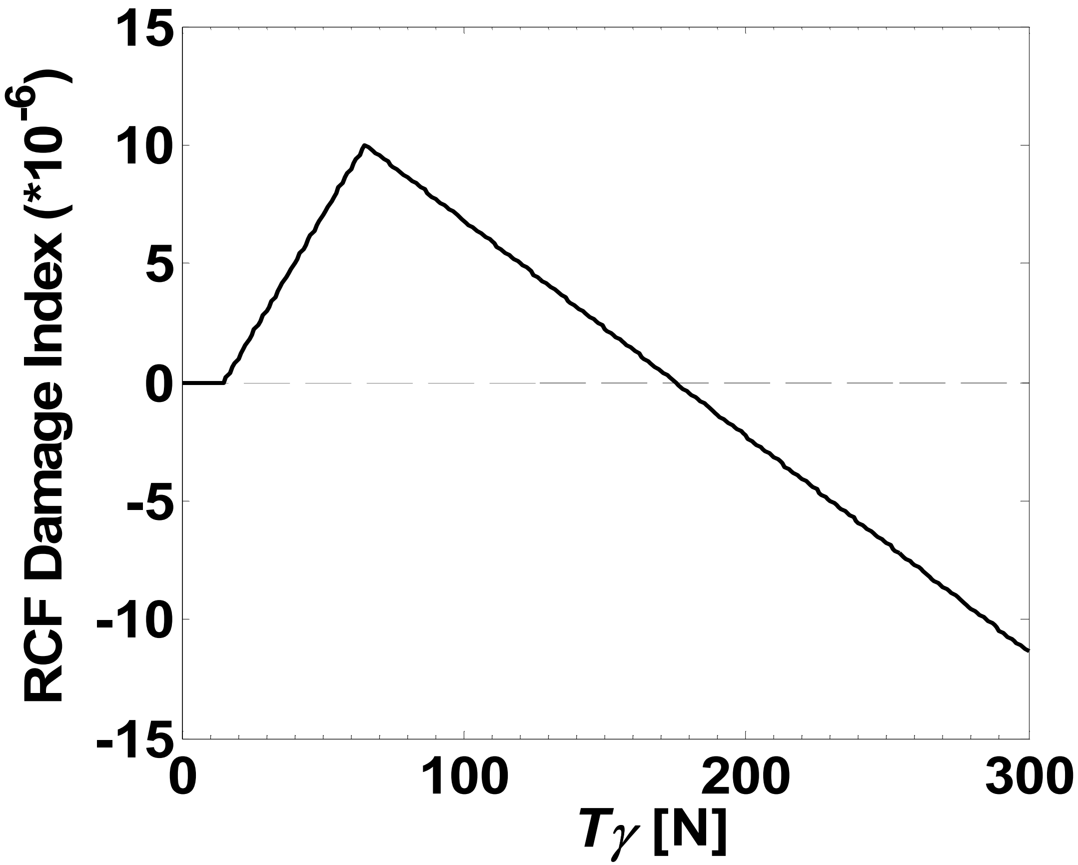
τ is the shear stress [N/m^2]

k is the yield stress in shear [N/m^2]

p is the contact pressure [N/m^2]

Methods – RCF models

- Rail RCF model based on $T\gamma$ (DI-model)



$$T\gamma = T_x \cdot \gamma_x + T_y \cdot \gamma_y$$

T_x is the longitudinal creep force [N]

T_y is the lateral creep force [N]

γ_x is the longitudinal creep [-]

γ_y is the lateral creep [-]

Methods – wear models

- Two wear prediction models have been studied and compared:
  - 1) wear model according to Pearce and Sheratt (based on the energy dissipation)
  - 2) Archard’s wear model

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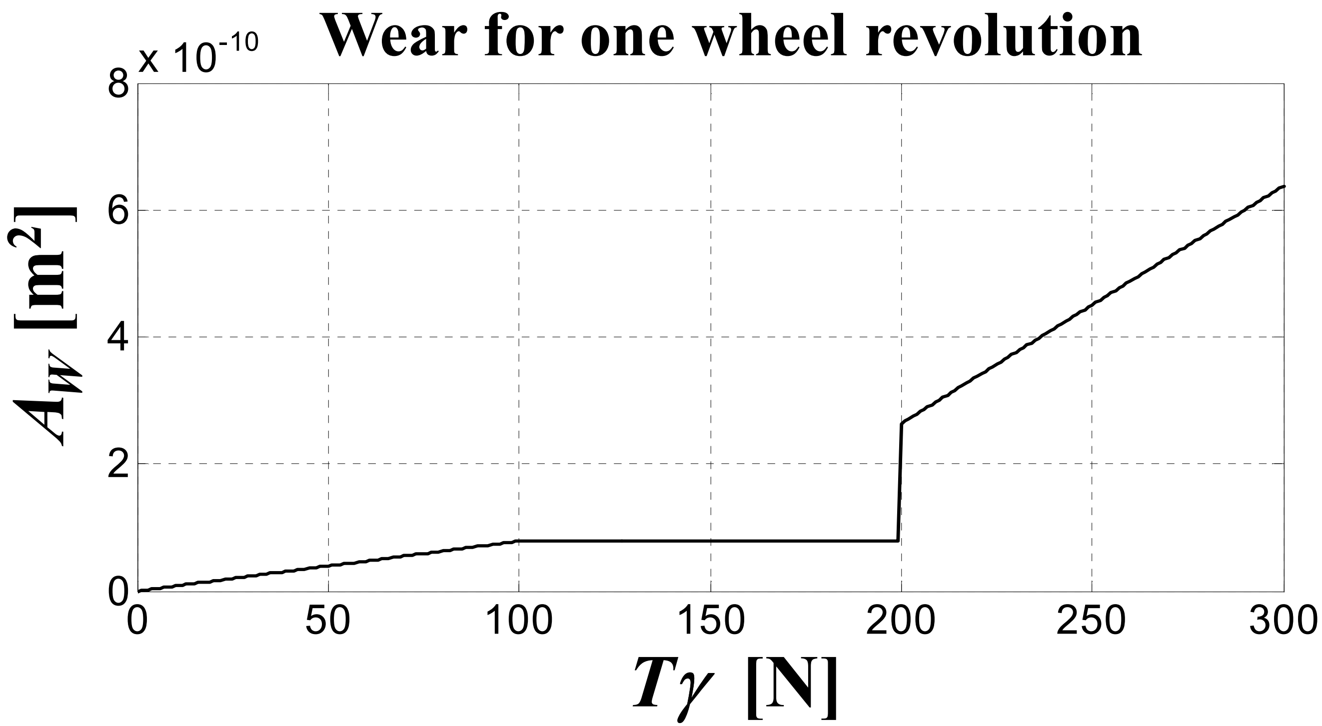
Methods – wear models

- Pearce and Sheratt (PSH) wear model



$$A_W = C \cdot T \cdot \gamma$$

A_W=worn-off area per wheel revolution

T=creep force

γ =creepage

Methods – wear models

- Archard wear model (AR)

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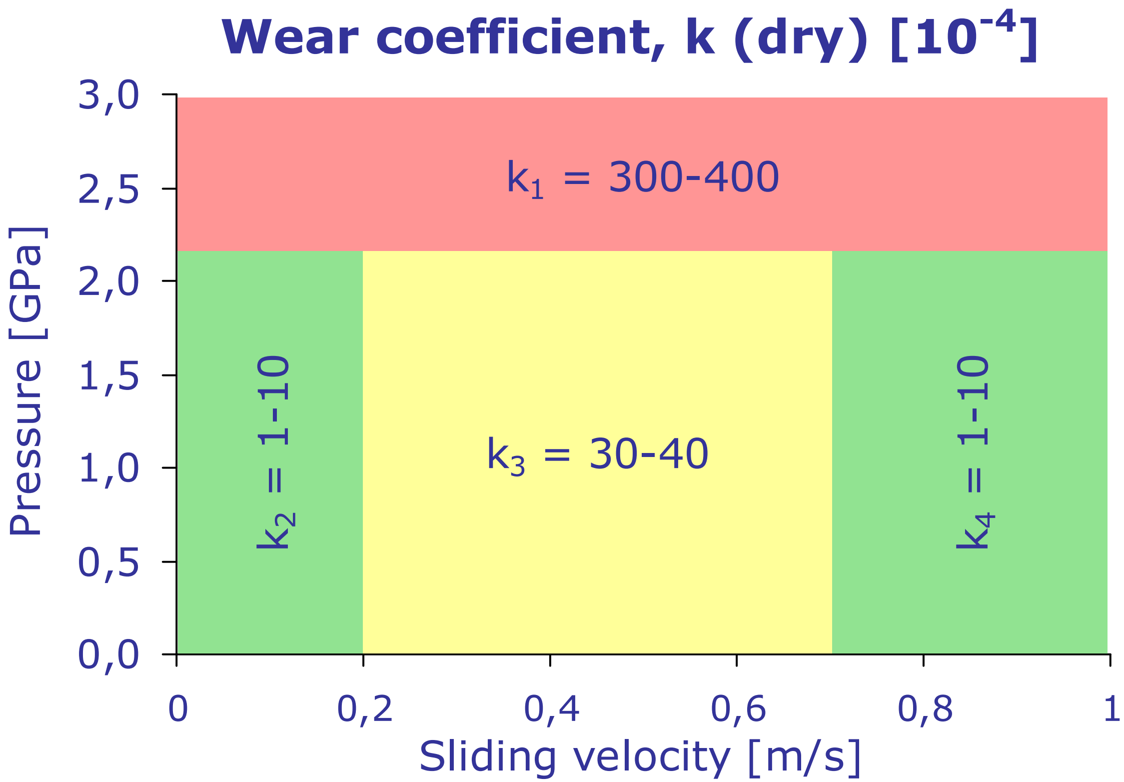
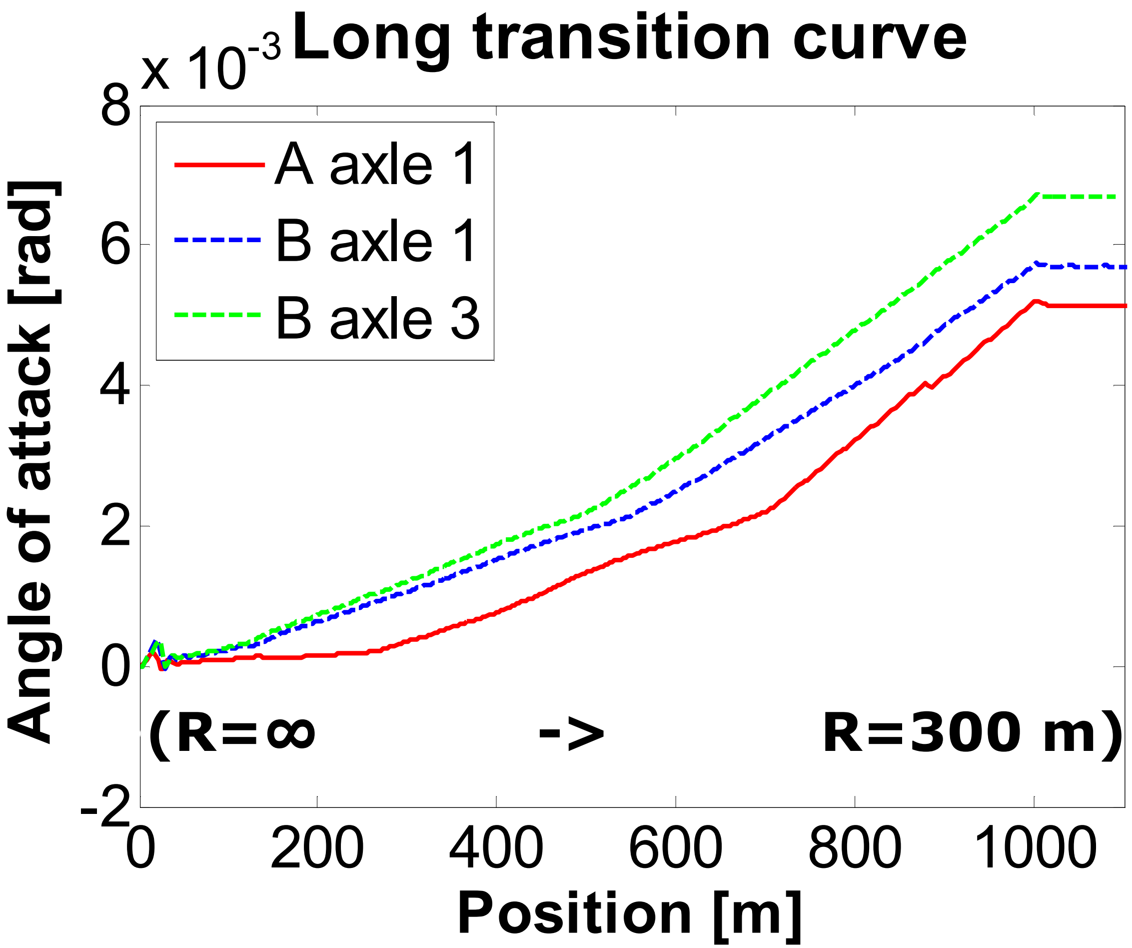
$$V_w = k \cdot \frac{N \cdot s}{H} \quad \Rightarrow \quad \Delta z = k \cdot \frac{p_z \cdot \Delta s}{H}$$

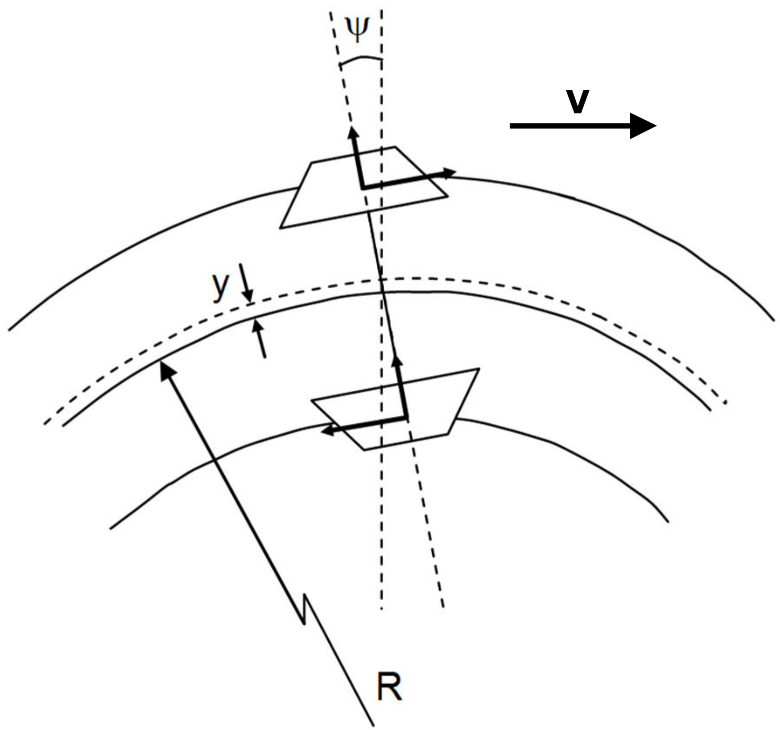
V_w = wear volume
s = sliding distance
N = normal force
H = hardness
k = wear coefficient
Δz = wear depth
p_z = contact pressure

Methods – wear models



Results - curving





Methods - simulations

R_m [m]	$V_{vehicle}$ [km/h]	Rail profiles	% of L_{tot}
338	60	1, 2, 3	2.4
432	74	1, 2, 3	2.7
574	92	1, 2, 3	8.0
676	98	1, 2, 3	6.7
895	113	1, 2, 3	6.0
1204	120	1	13.5
2035	120	1	15.5
Straight	120	0	44.9

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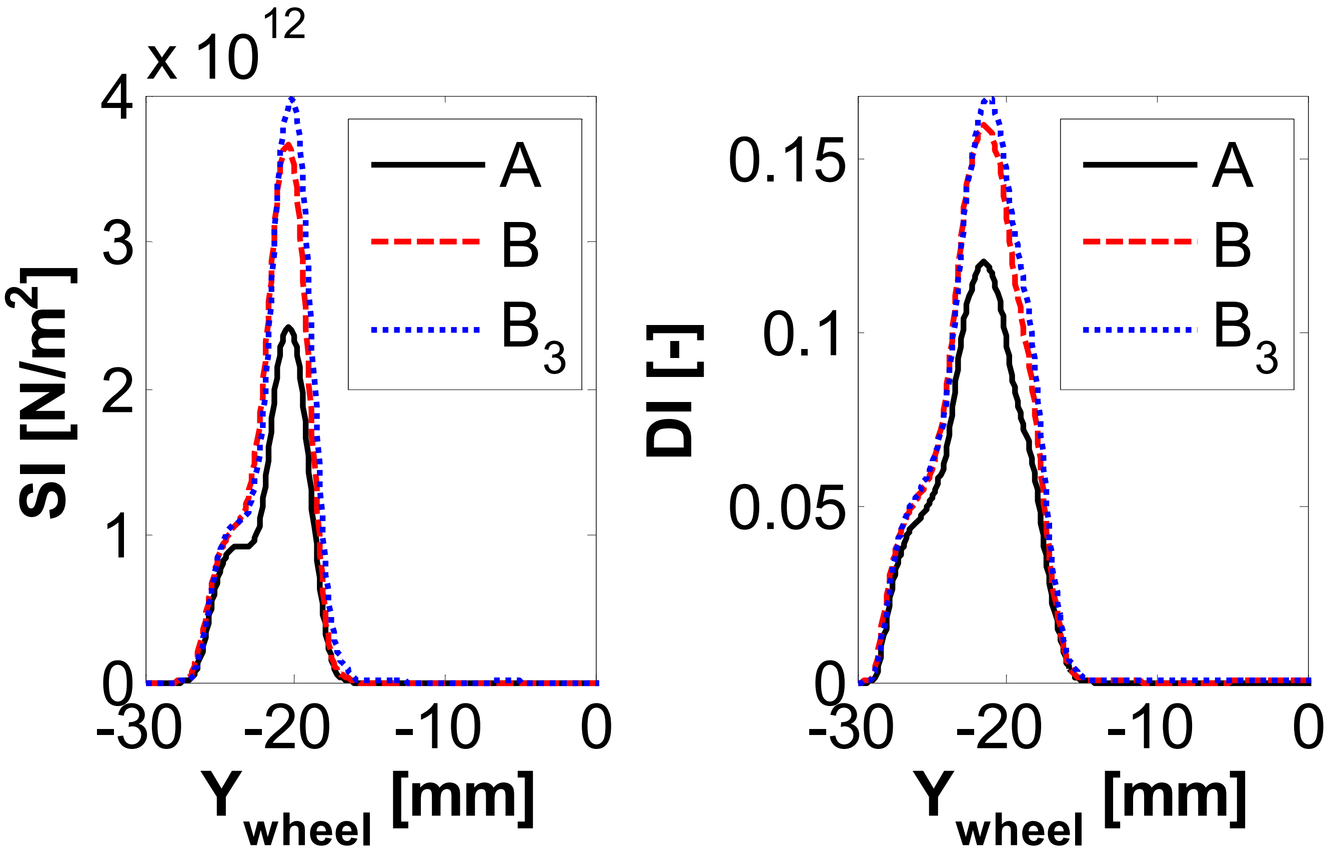
Results - RCF

- Calculated RCF damage on wheel profile



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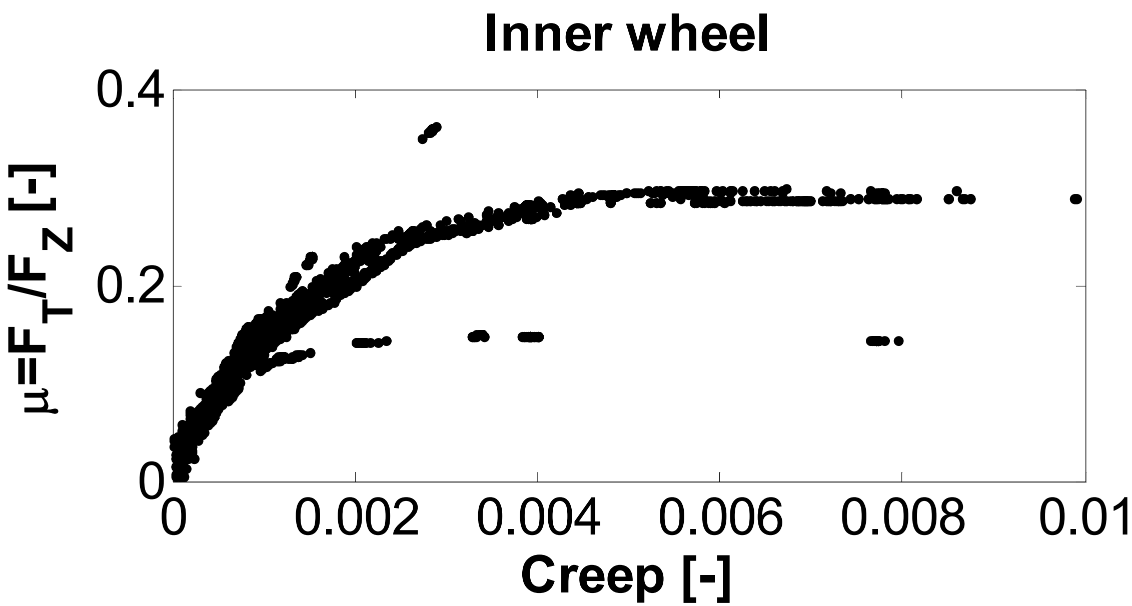
Results - RCF

- Limitation of the creep forces for high creepages (full slip) for SI-model.

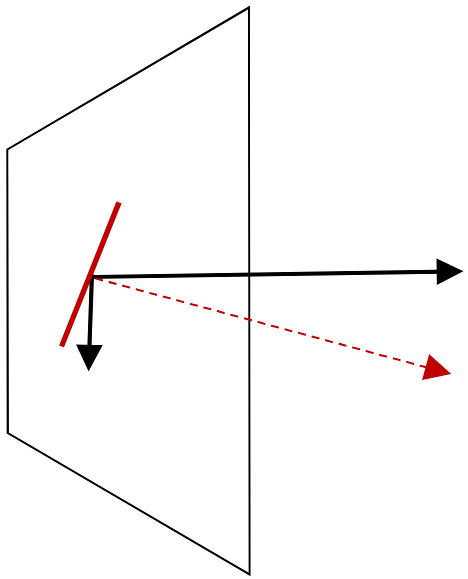


$$SI = \frac{F_T}{F_z} \cdot p_0 - k > 0$$

$$DI : T\gamma = T_x \cdot \gamma_x + T_y \cdot \gamma_y$$

RCF inspections vehicle B

High lateral creep forces



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Results - wear

- Calculated wear depth on wheel profile

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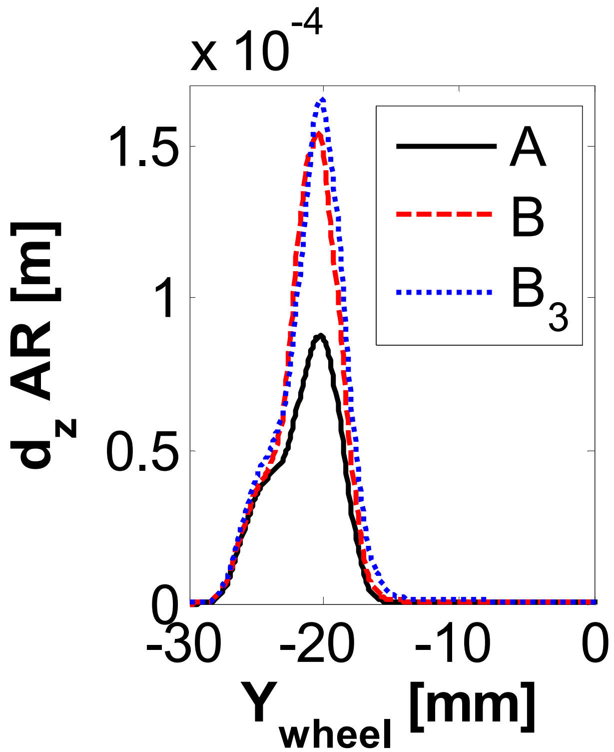
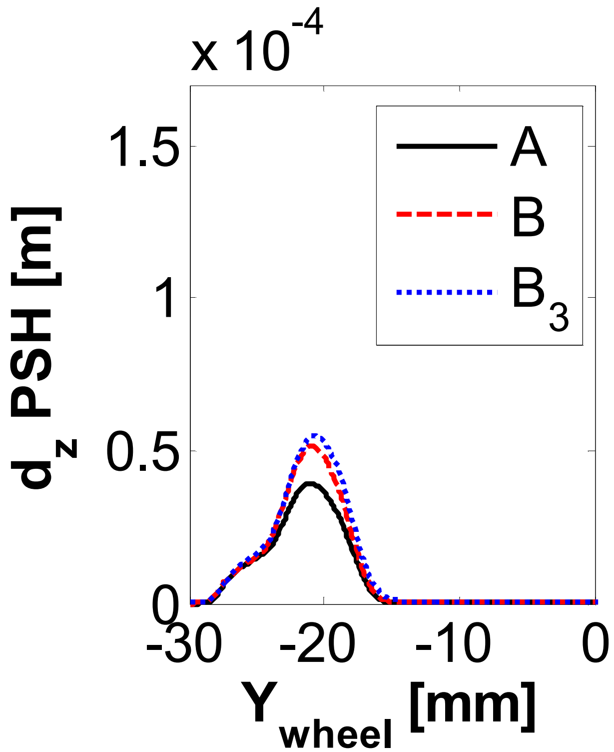
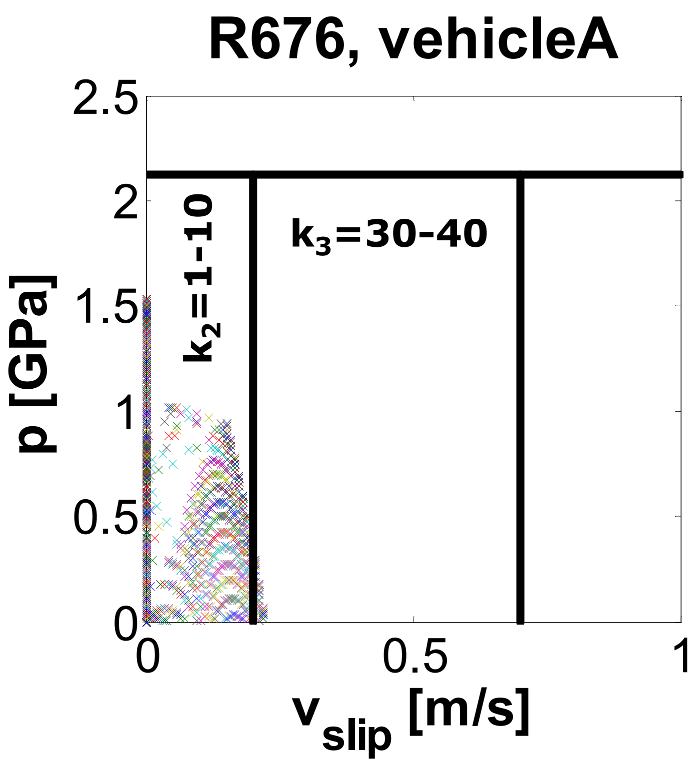
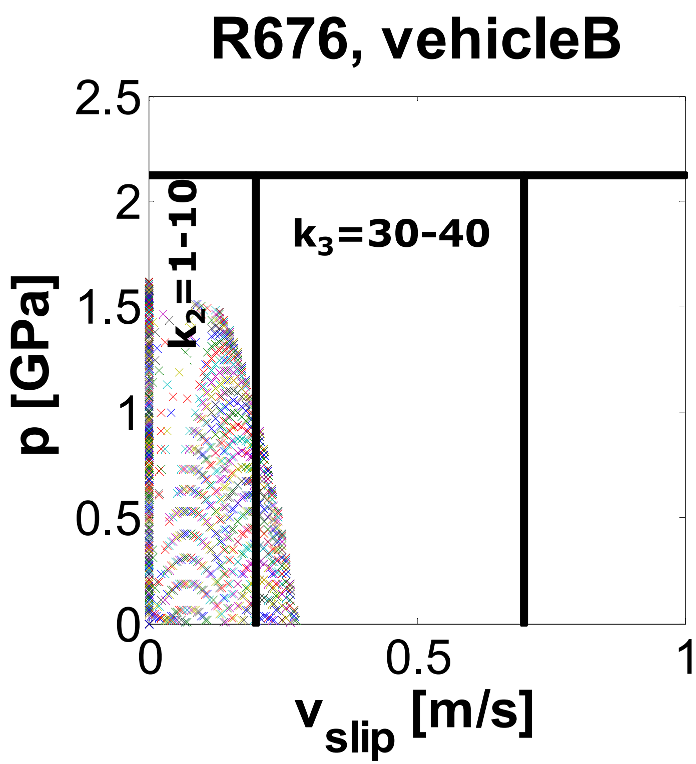




Results - wear

- Wear map for single contact in curve





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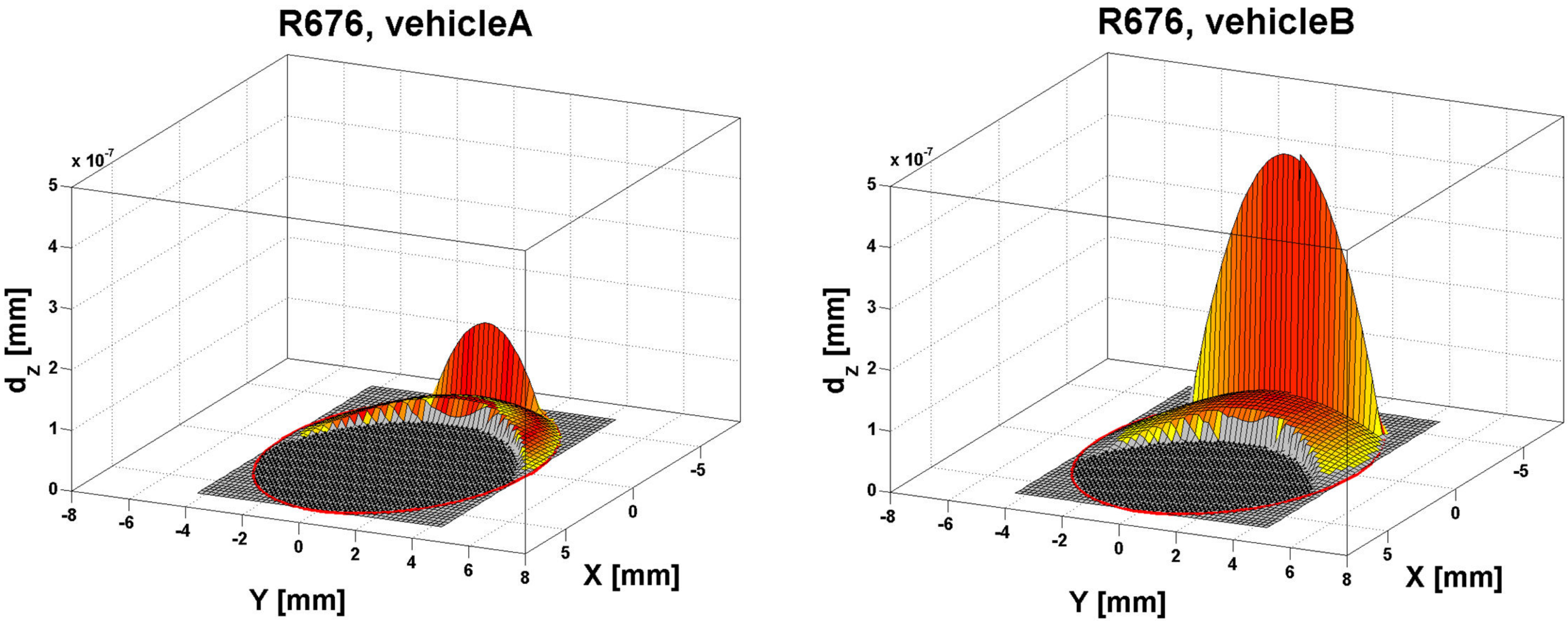
Results - wear

- Calculated wear depth d_z for single contact



Conclusions

- The following main conclusions can be drawn for the RCF prediction models:
    - Both RCF models predict more damage for vehicle B than for vehicle A due to the better steering performance of vehicle A
    - Under poor adhesion conditions, however, the models behave differently:
        - The SI-model predicts less damage for high creepages, due to the independence on creepage
        - Previous research, however, has also shown that high creepage has no effects on RCF life.
- The RCF inspections of the wheels of vehicle B show that the steering of the axles under certain circumstances can be poor.

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Conclusions

- The following main conclusions can be drawn for the wear prediction models:
    - o Both wear models predict more wear for vehicle B than for vehicle A due to the better steering performance of vehicle A
    - o The Archard's wear model predicts more wear due to the large influence of the sliding velocity in the wear map, therefore, especially for vehicle B.

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Thank you for listening!