Dynamic Modelling of Iron-Ore Freight Wagons with 3-P Bogies
RCF Investigation

ROYAL INSTITUTE OF TECHNOLOGY

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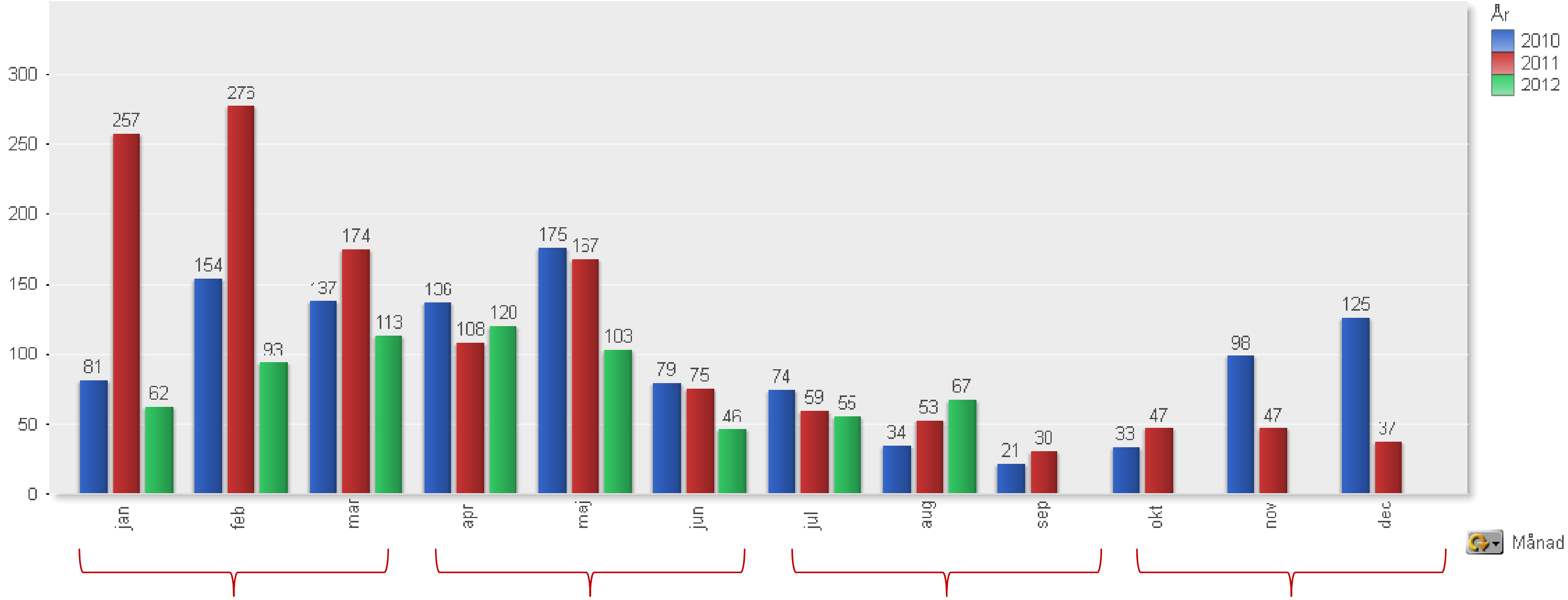
Devastating RCF problem in winters.

3 136 st



707 st

350 st

142 st

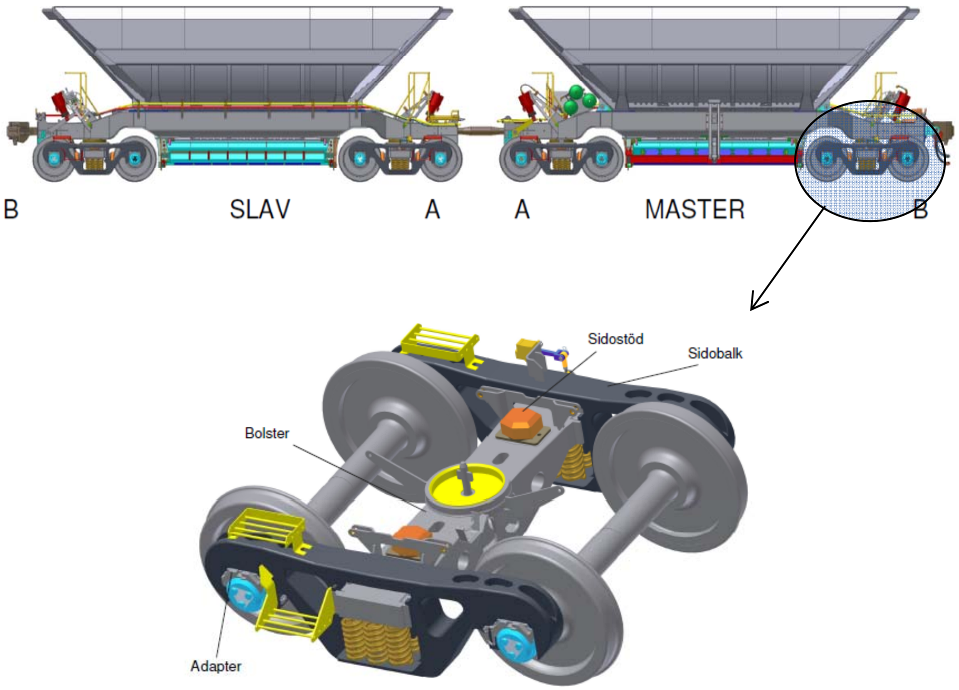
131 st

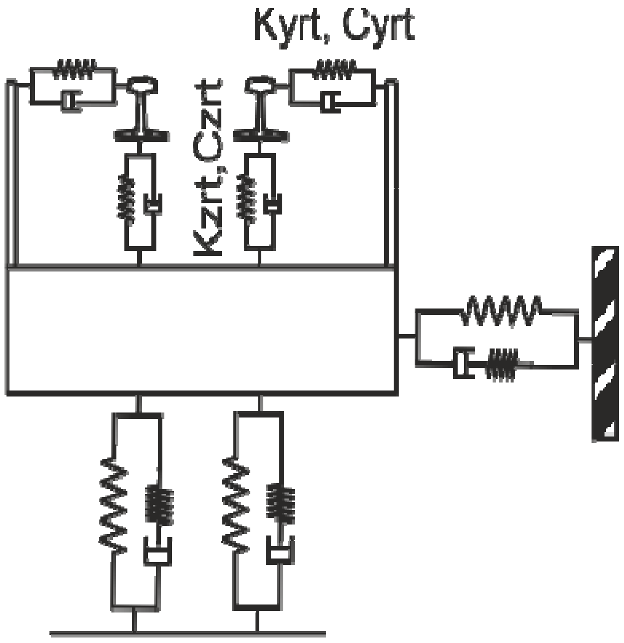
Investigated Parameters on wear and RCF

- Influence of Concrete Sleepers compared to wooden sleepers
- Influence wheel-rail Coefficient of friction
- Influence of the worn and new wheel Profiles
- Influence of the seasonal variations of track stiffness

Background

The model is built using MbS software Gensys and validated against measurement via comparing lateral and vertical carbody accelerations in 2011 at KTH .

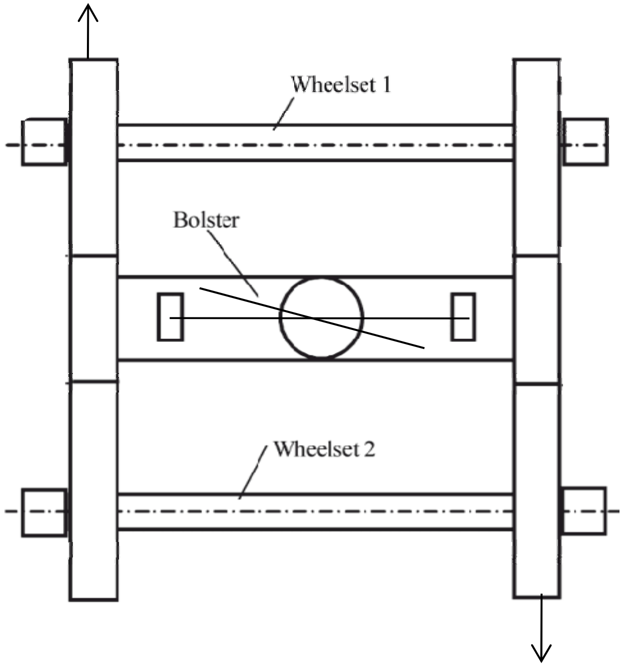


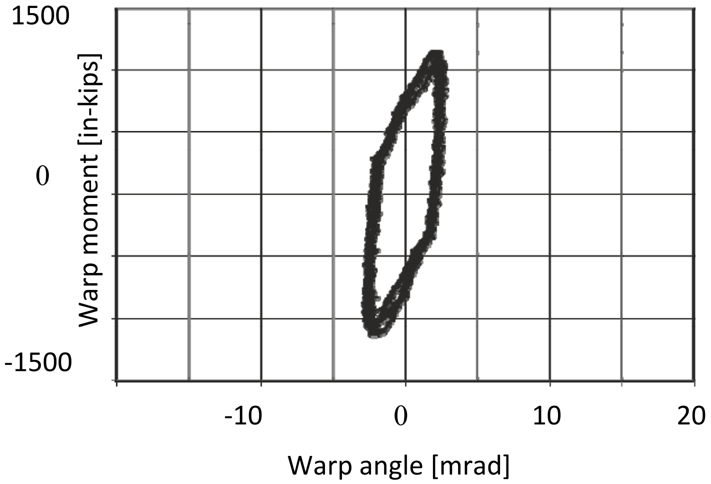


Background

Major improvements in the model:

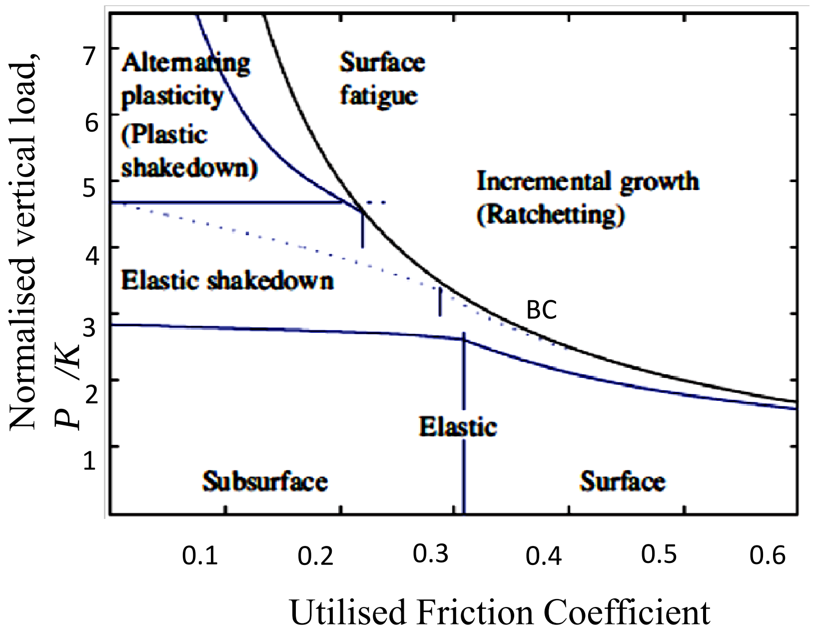
- Variable rail profiles
- Stiffer Vehicle by adding a yaw damper in the secondary suspension (Simulating the warping stiffness)



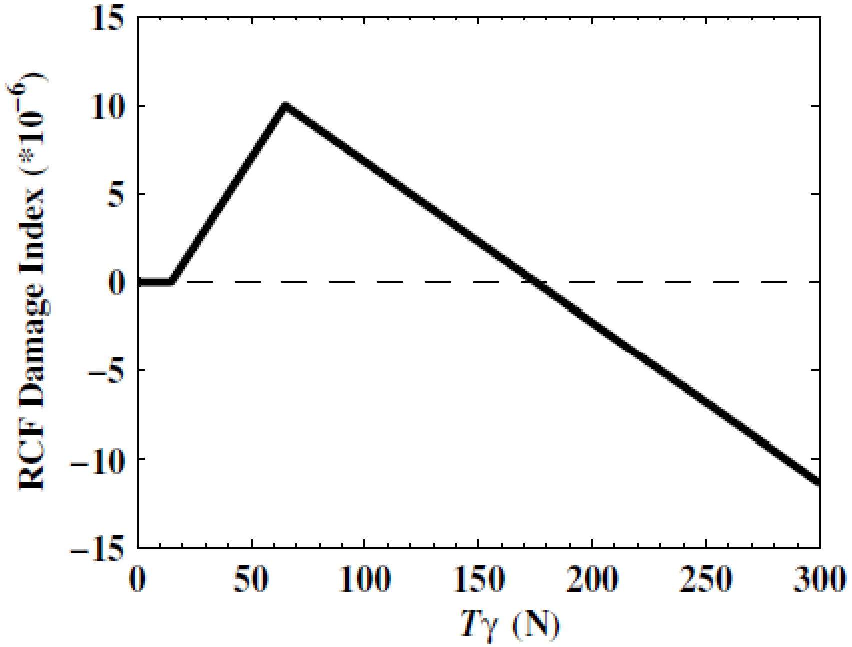


Method

- Shakedown diagram on surface initiated RCF (High axle load and μ > 0.35) and Fatigue Damage Function



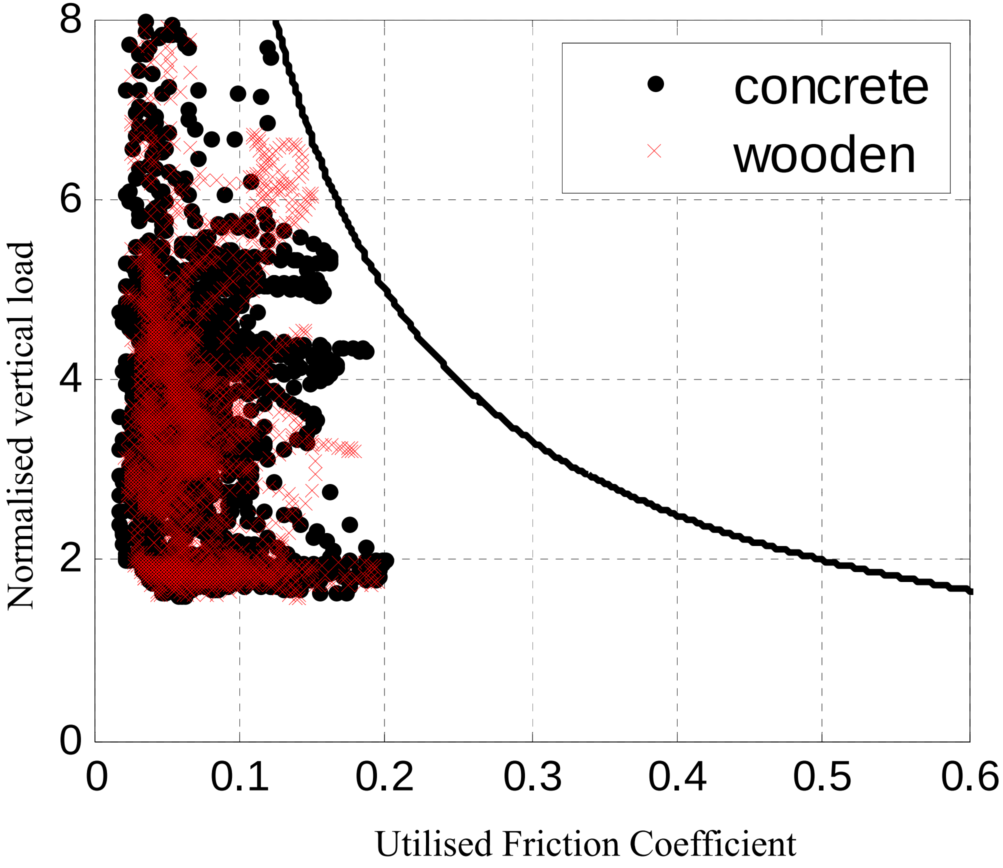
$$\mu = \frac{F_T}{F_z} = \frac{\sqrt{F_x^{2} + F_y^{2}}}{F_z}$$



Wear is assumed to be proporsional to the Energy dissipation

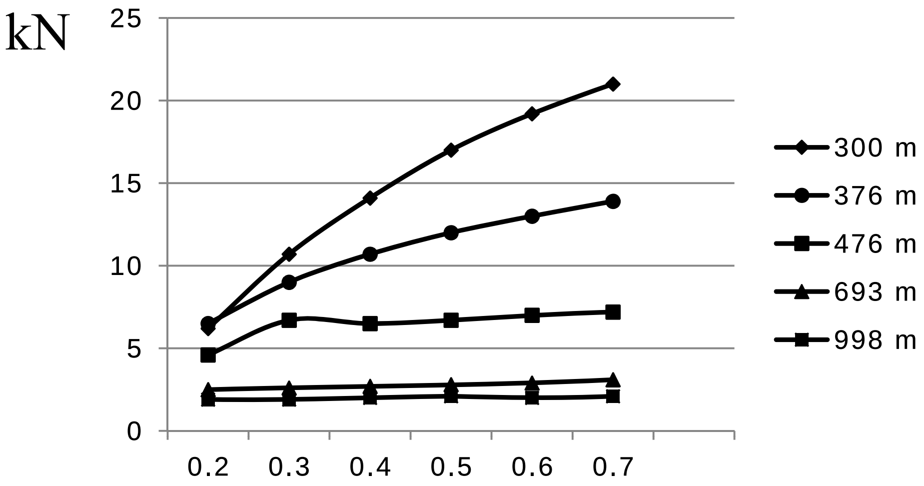
K=material yield stress in shear

Influence of concrete sleepers compared to wooden sleepers

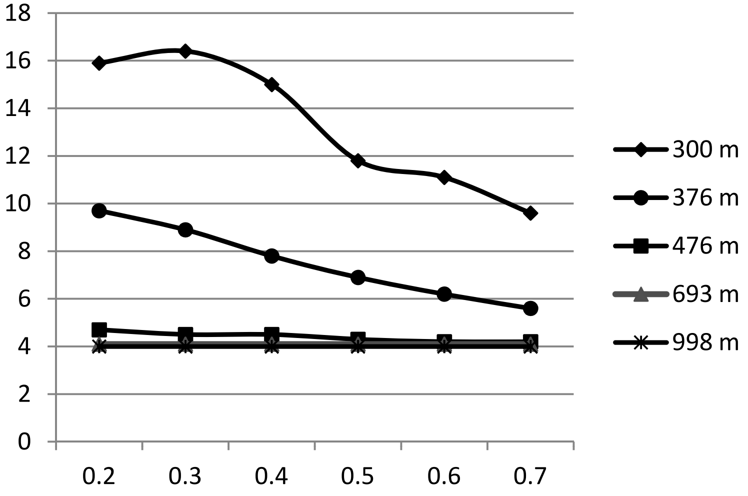


Shakedown map, low pass filtered response from simulated operation on curve with radius of 476m and mild track irregularities with cut-off frequency 20 Hz. The wheel-rail friction coefficient is 0.4.

Influence of wheel-rail Coefficient of friction



dependency of the longitudinal creep forces to the wheel-rail friction coefficient

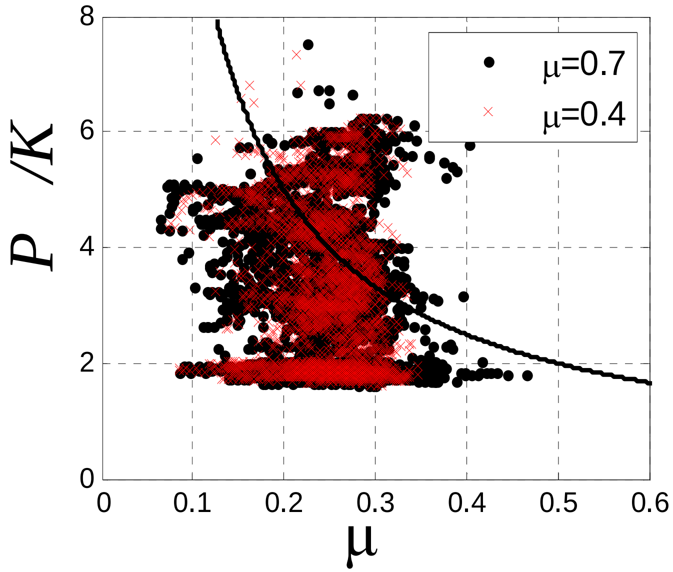


dependency of the lateral creep forces to the wheel-rail friction coefficient

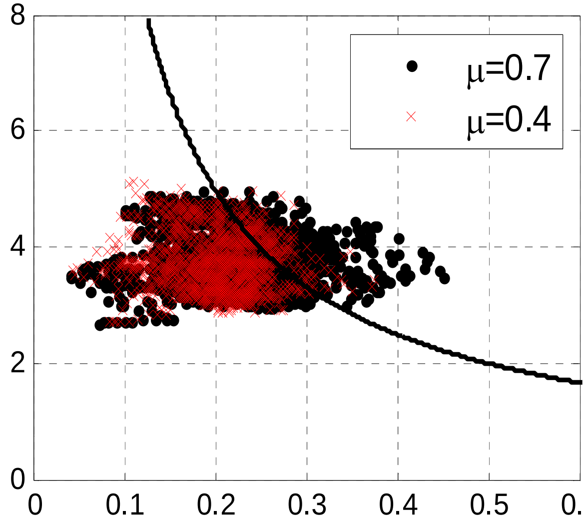
$$\mu = \frac{F_T}{F_z} = \frac{\sqrt{F_x^2 + F_y^2}}{F_z}$$

Influence of wheel-rail Coefficient of friction

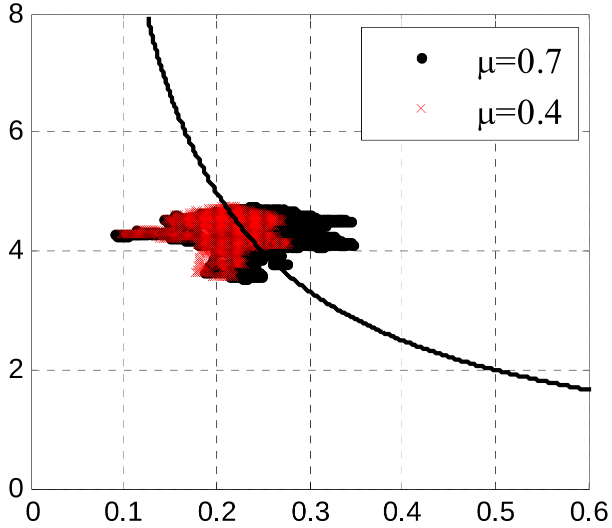
Mild Irregularities



Large Irregularities



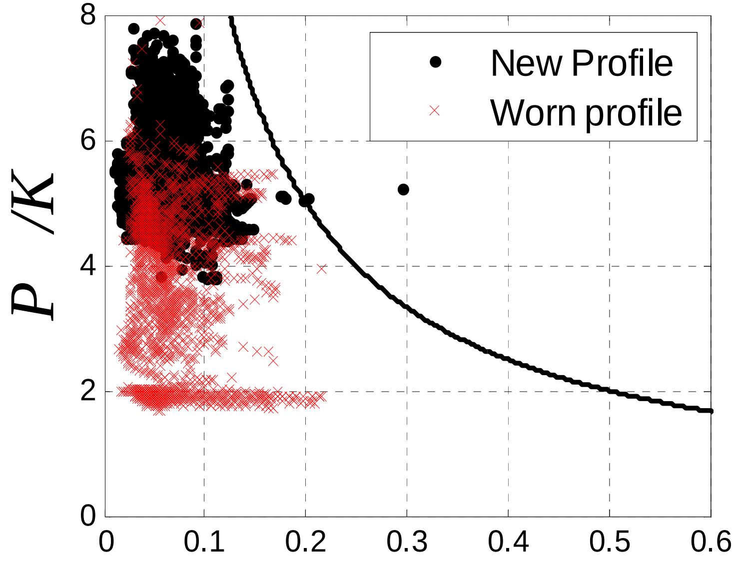
Very large Irregularities

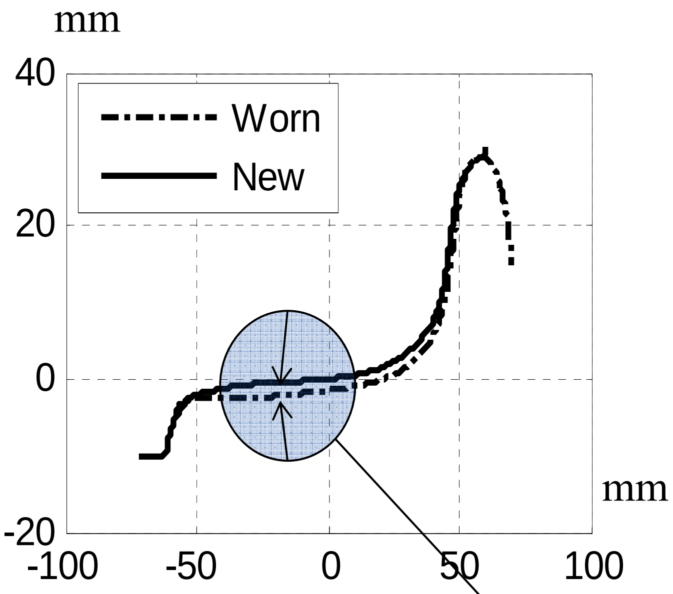


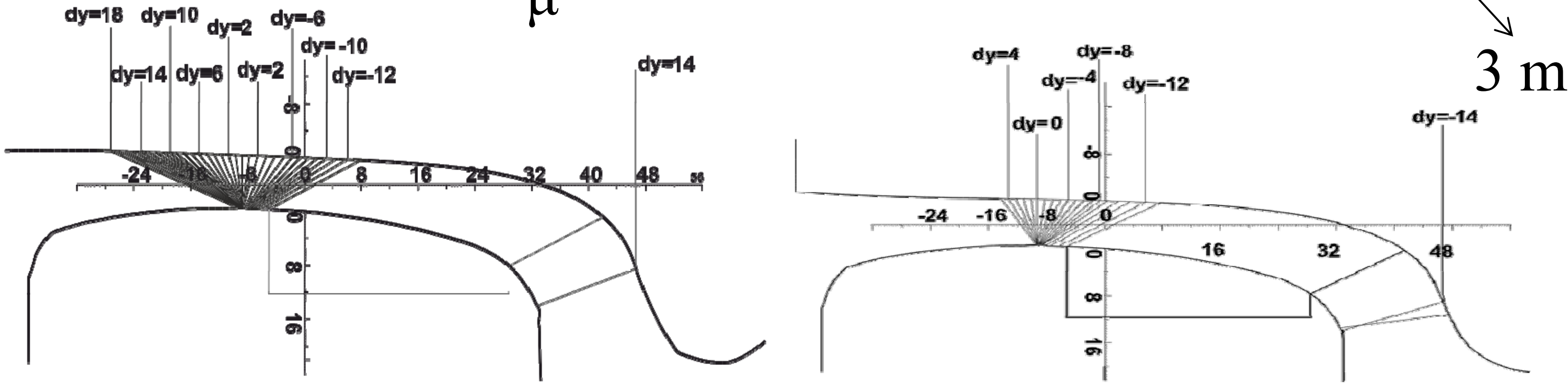
In the track with more moderate irregularities the longitudinal and lateral forces compensate each other more. Therefore, in this case, the probability of RCF is not that dependent on the friction coefficient.

- Curve radius=300m

Influence of wheel profile (WP4)





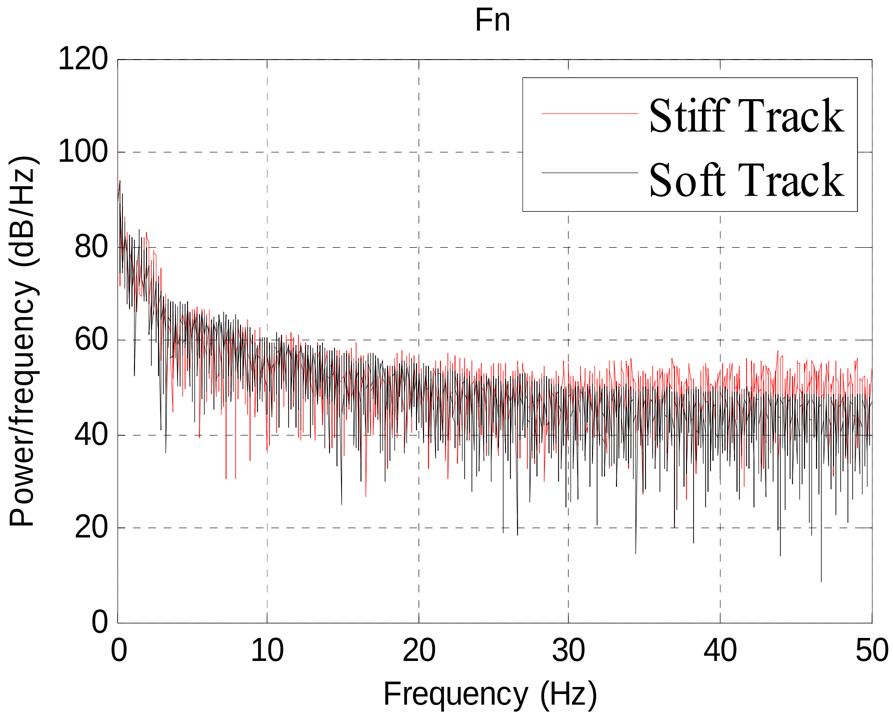


Contact point positions on wheel and rail for different relative lateral displacements. Worn wheel profile (~150’000 Km) left and new wheel profile right.

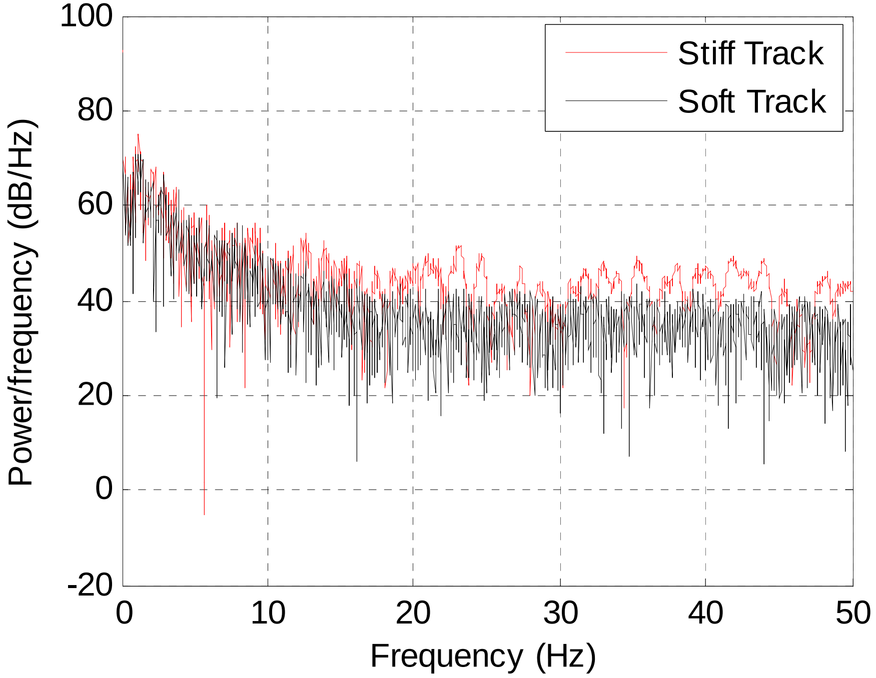
- Curve radius=476m

Influence of seasonal variations of the track stiffness

The vertical rail-track stiffness (*Kzrt)* and viscous damping *(Czrt)* are reduced and increased by a factor of ten.



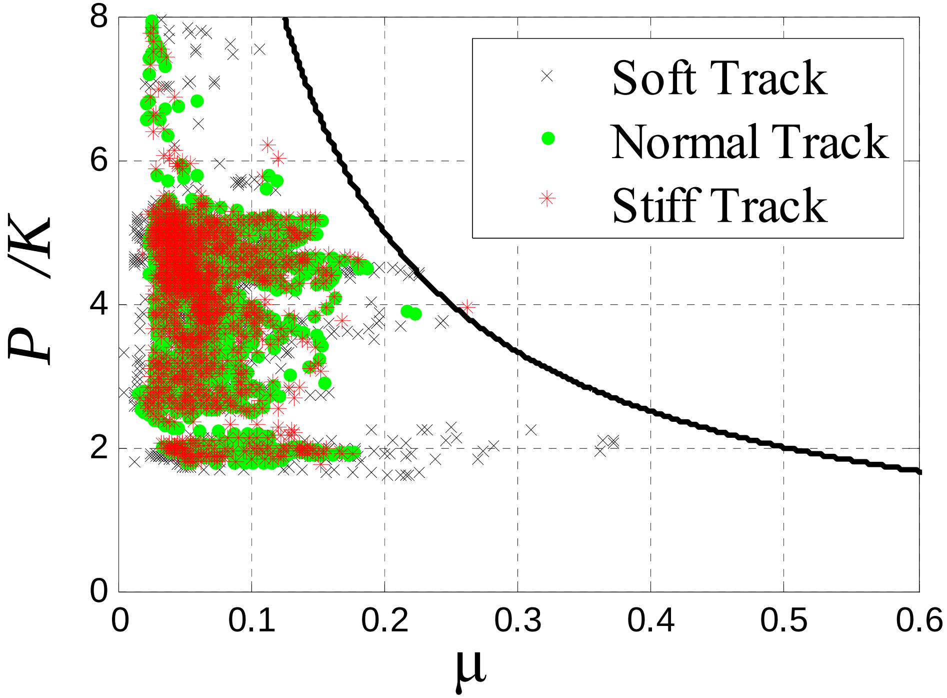
Normal Contact forces



Tangential creep forces

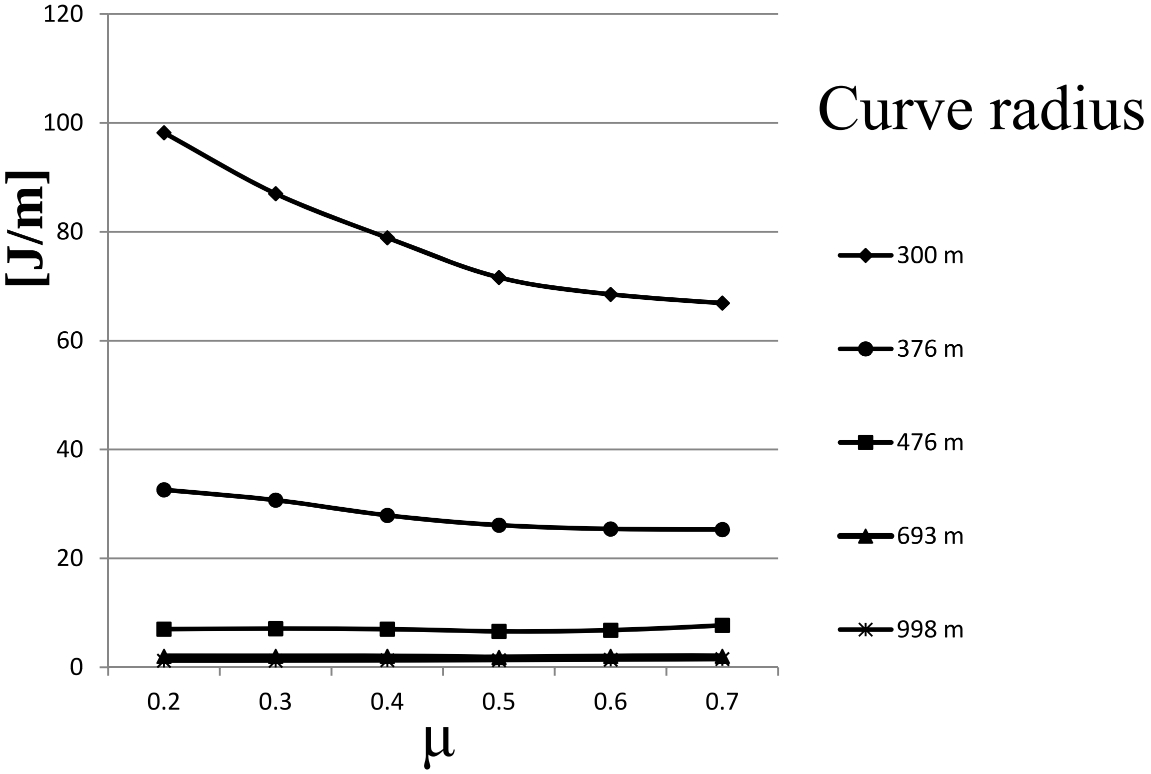
Influence of seasonal variations of the track stiffness

No significant difference is observed regarding RCF and the wear number. Moreover, there has not been any study showing that the frequency of the forces affects the RCF of the wheels.



•Curve radius=476m

Wear and RCF



At poor adhesion more sliding is needed to steer the vehicle which results in higher dissipated energy, while these values become almost independent of the friction level at adequate adhesion since the steering capability is sufficient.

Conclusions

- The effect of both concrete and wooden sleeper track on the wear number and RCF probability is studied and it does not show any significant difference.

- The new wheel profile is more vulnerable regarding RCF.

- A parametric study applied on the wheel-rail friction coefficient shows its significant impact on the RCF. This dependency is even more pronounced with larger track irregularities.

- The effect of seasonal variations of track stiffness is investigated, and it cannot be concluded that it is the main reason for severe RCF during winter.

- RCF will happen on the tread of the inner wheels while negotiating curves below approximately 450 m radius

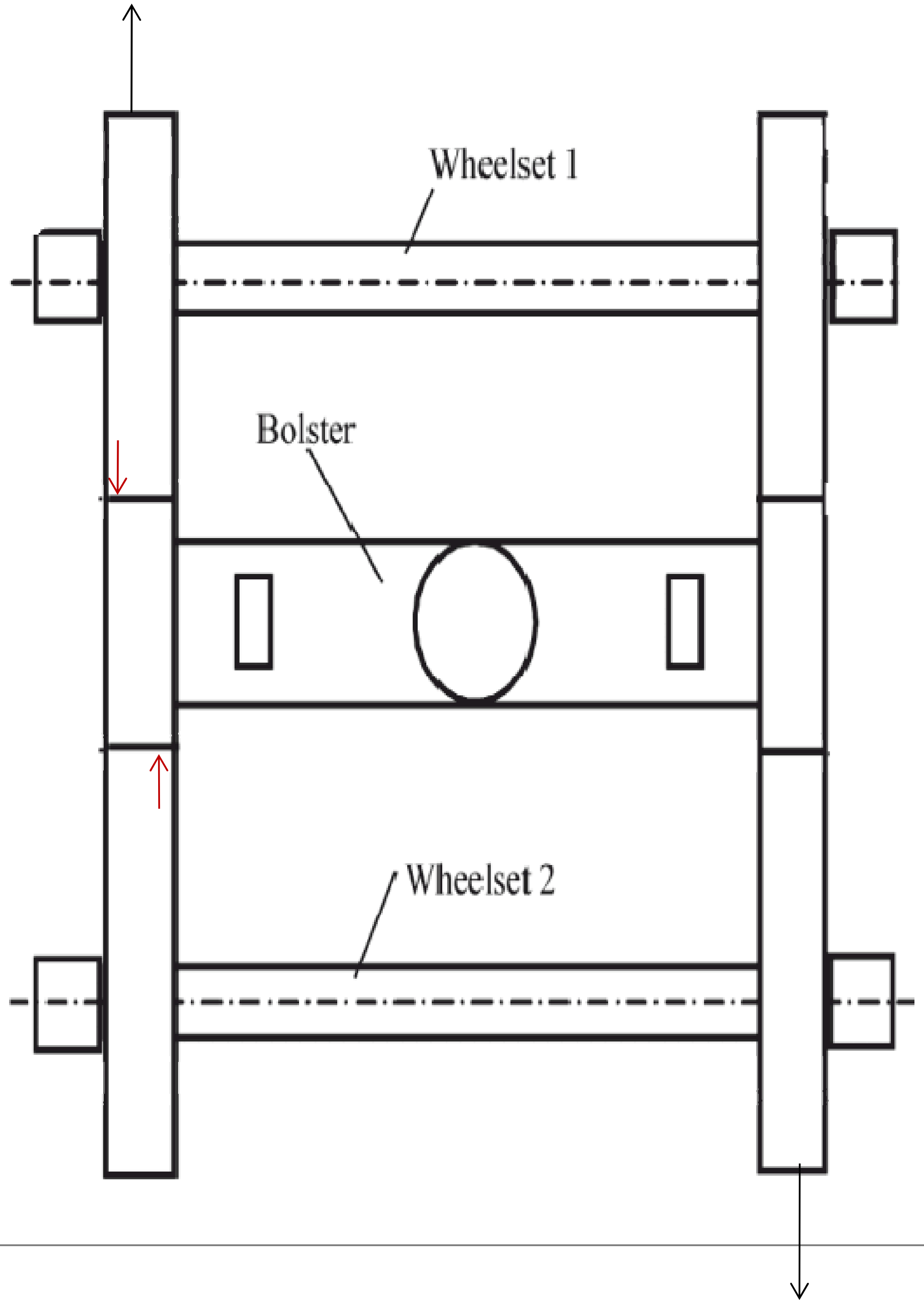
Conclusion

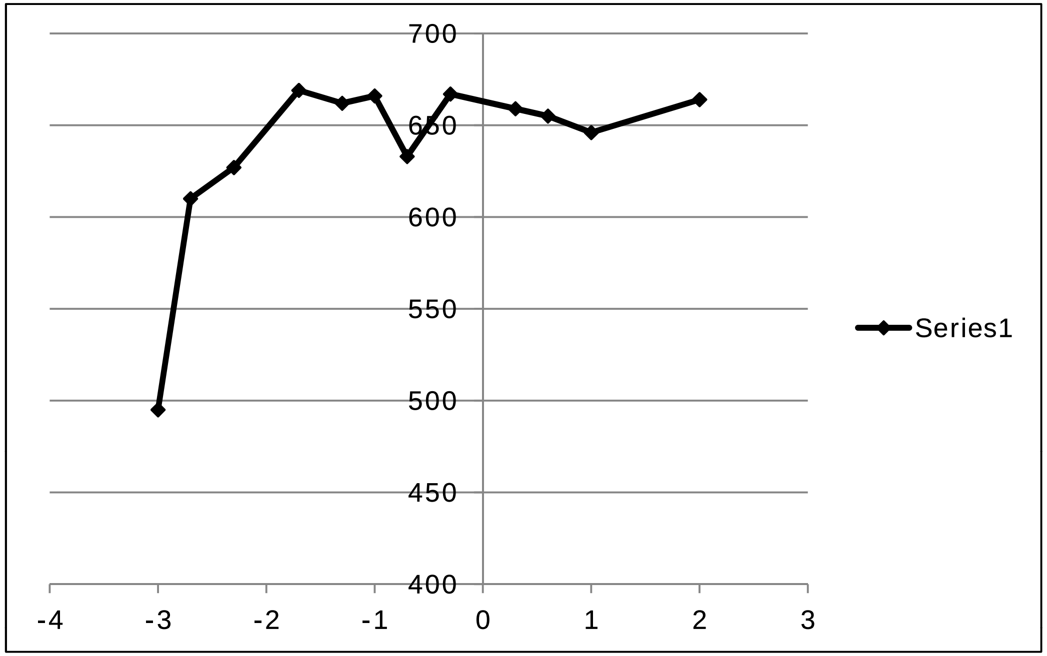
- In cold dry winters when the wheel material behaves more brittle raising the wheel-rail friction coefficient significantly increases the risk of RCF while the wear rate is not high enough to wear out the initiated cracks.

Future work

- Improving the model and validate it against the measured Track Forces as it is validated only via comparing the acceleration.
    - Comming measurement on track stiffness in winter.
- Investigation of the effects of further increasing the axle load on the wheel-rail interaction.
- Investigation of the possibility of increasing the speed of the iron ore trains.
- Optimization of wheel profiles to minimize the costs of wear and rolling contact fatigue. **MiW Konsult AB**

Thank you very much for your attention


Wheelset 1
Bolster
Wheelset 2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650
600
550
500
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400
-4
-3
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0
1
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3
Series1