Investigation of the risk for Rolling Contact Fatigue on wheels of different passenger trains

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SIMPACK UM 2007, Bonn

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Background

During the last years RCF has become more common also on passenger trains which resulted in wheel damages and more frequent reprofiling and reduced the life time of the wheels.

Therefore in this study different trains have been compared regarding their risk to develop RCF on the wheels by calculating the contact conditions between wheel and rail during curving with the multibody simulation tool SIMPACK.

The overall aim of the study is to develop criteria that indicate the risk for RCF already in the design stage of the vehicle.

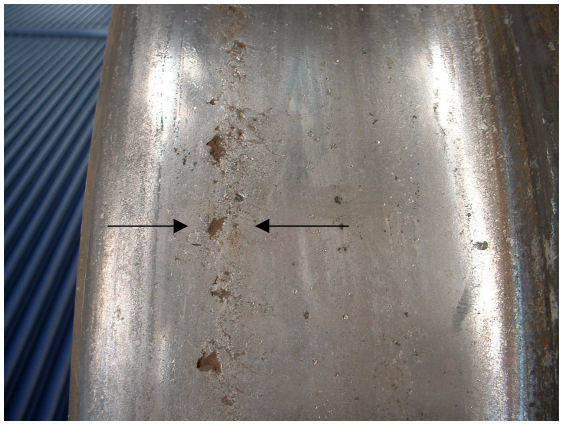
The phenomenon of Rolling Contact fatigue

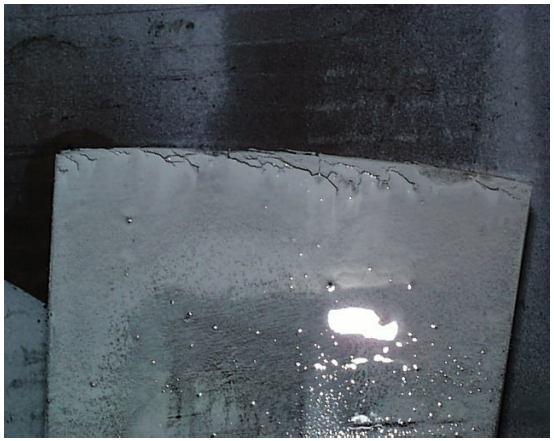
- **Surface-initiated fatigue sometimes denoted as spalling**
- **Subsurface-initiated fatigue sometimes denoted as shelling**
- **Fatigue initiated at deep defects, sometimes denoted as deep shelling or shattered rims**

Phases of surface initiated fatigue

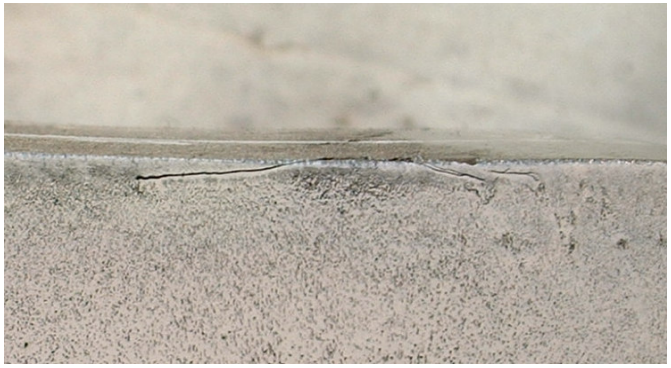
- Crack initiation
- Crack propagation
- Crack branching towards tread surface and wheel web
- Final fracture due to single overloads

Visual appearance of spalling



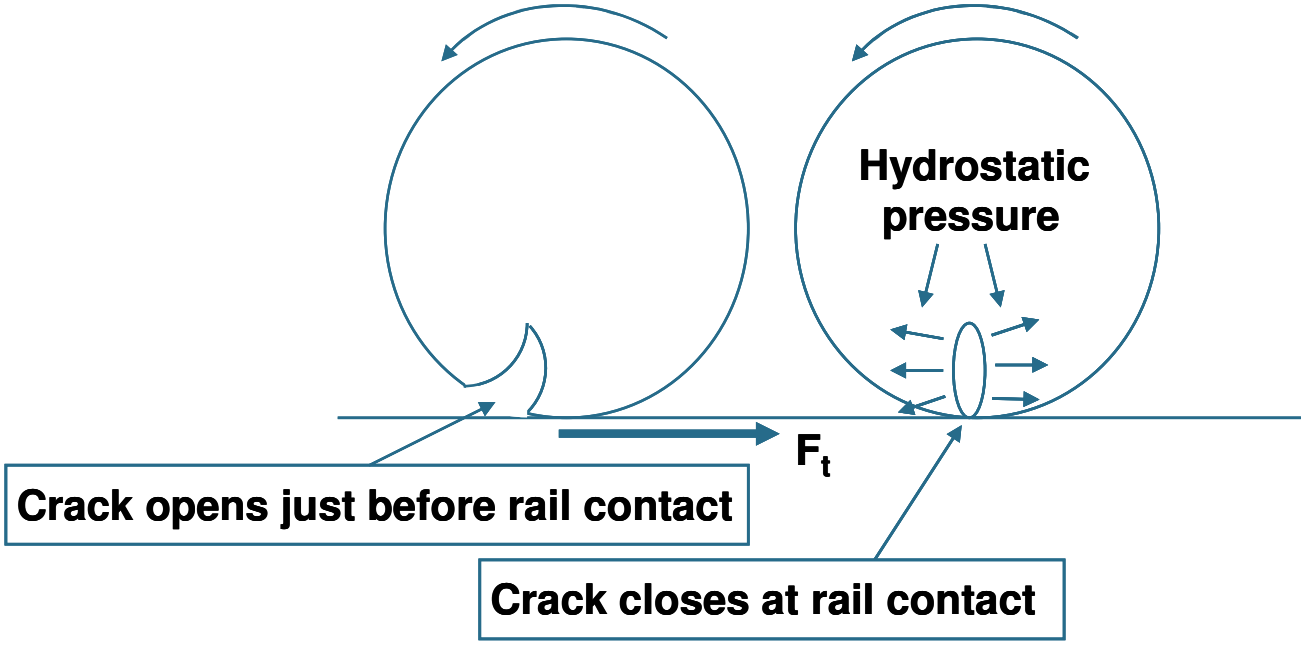


Circumferential section



Cross section

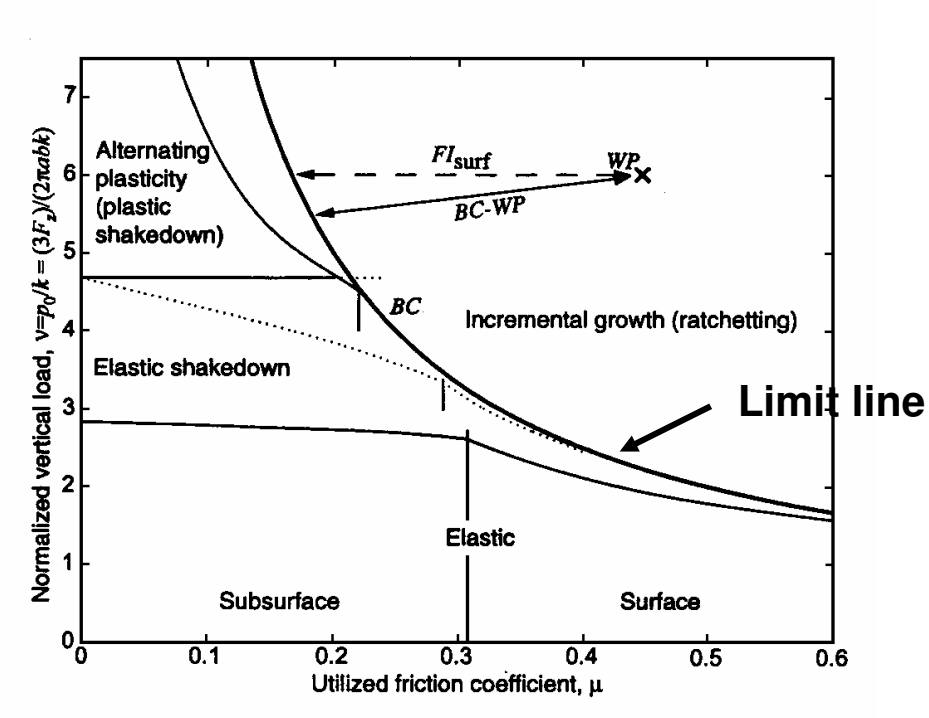
Effect of trapped fluid on crack propagation



Two criteria tested

- **Shakedown map and fatigue index**
  - developed by Chalmers, Gothenburg
- **RCF damage function (Tγ)**
  - developed by AEA Technology

Shake down map and fatigue index

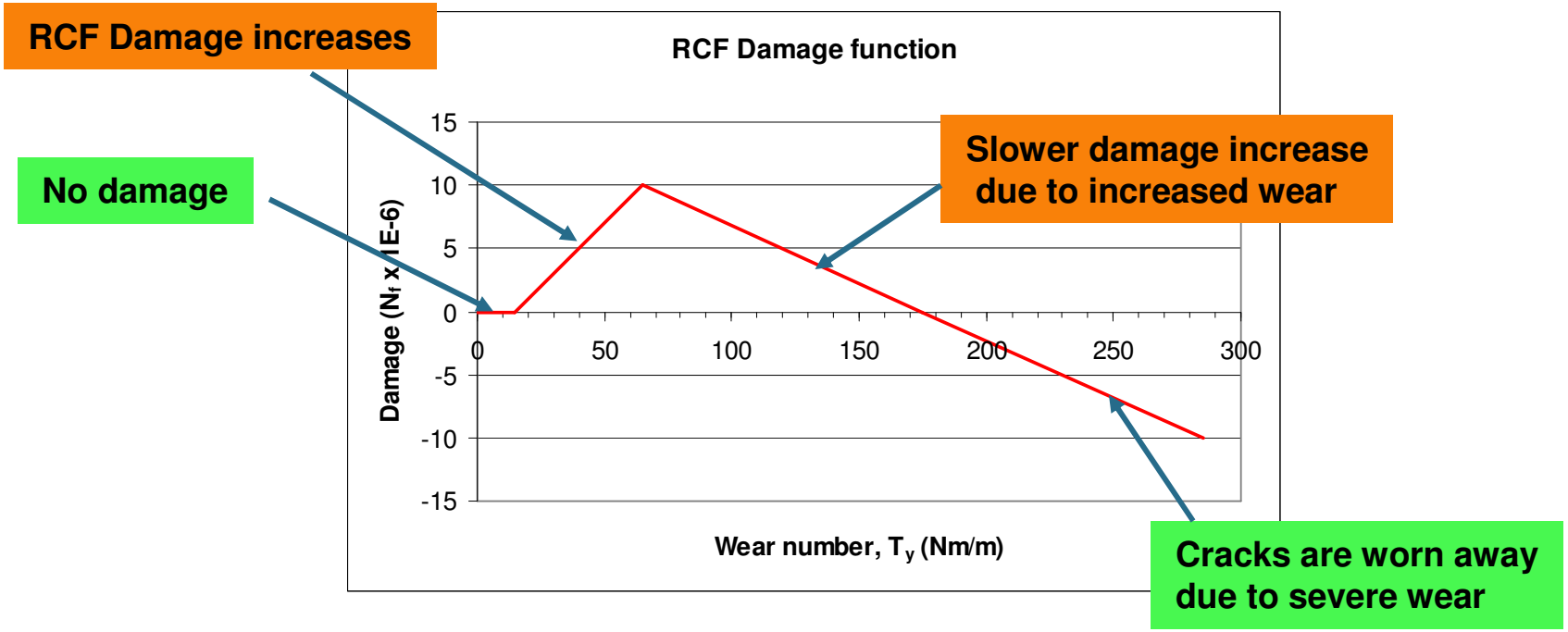


Fatigue index developed by Chalmers (Gothenburg)

$$FI_{surf} = \mu - \frac{k}{p_0} = \mu - \frac{2\pi abk}{3F_\zeta}$$

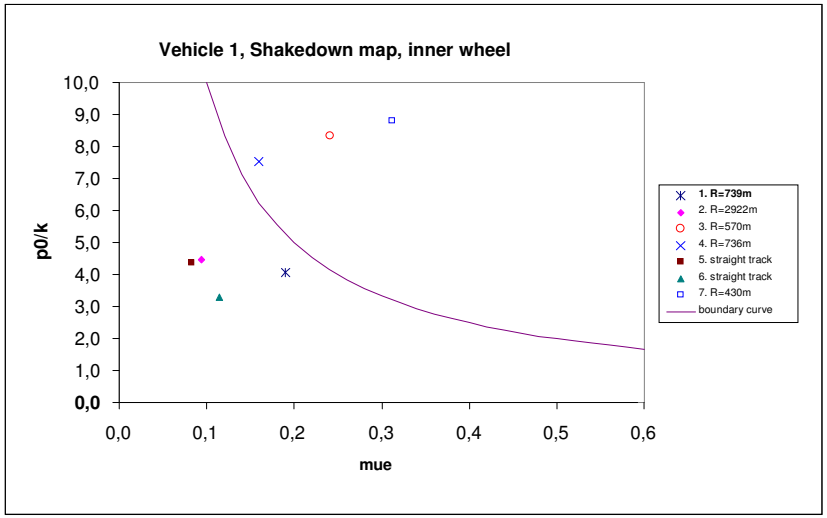
RCF damage function

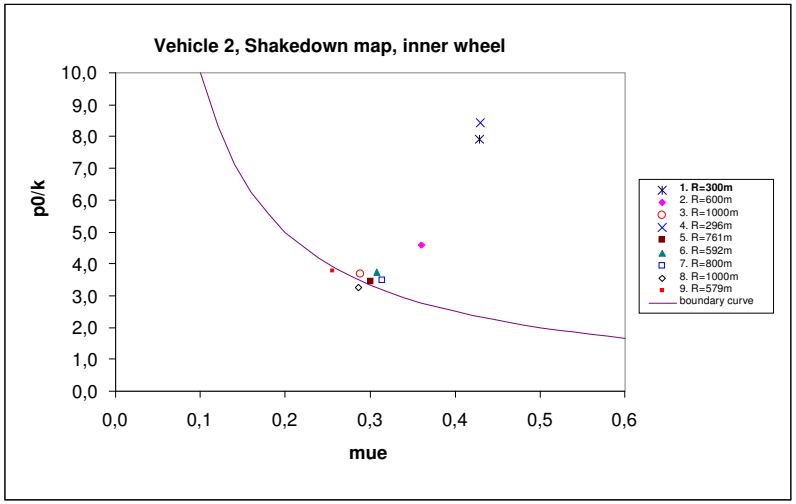
Developed by AEA Technology
- four different areas

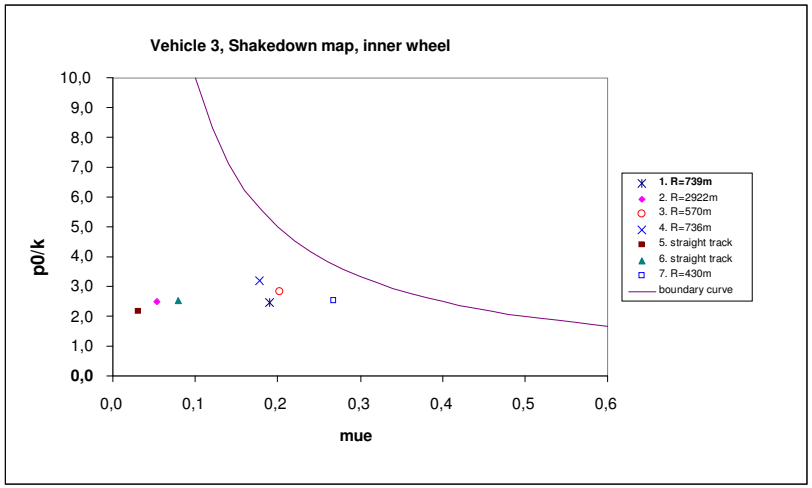


$$T\gamma = T_x\nu_x + T_y\nu_y$$

Shakedown evaluation







Vehicles 1 and 2 suffer from RCF

Vehicle 3 does not suffer from RCF

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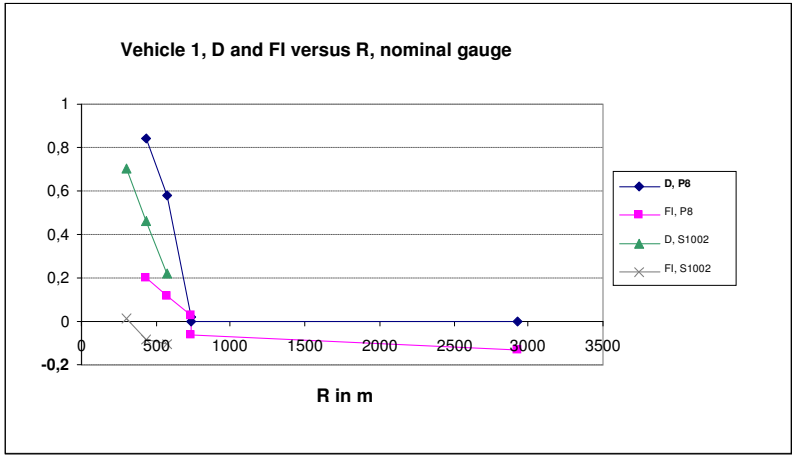
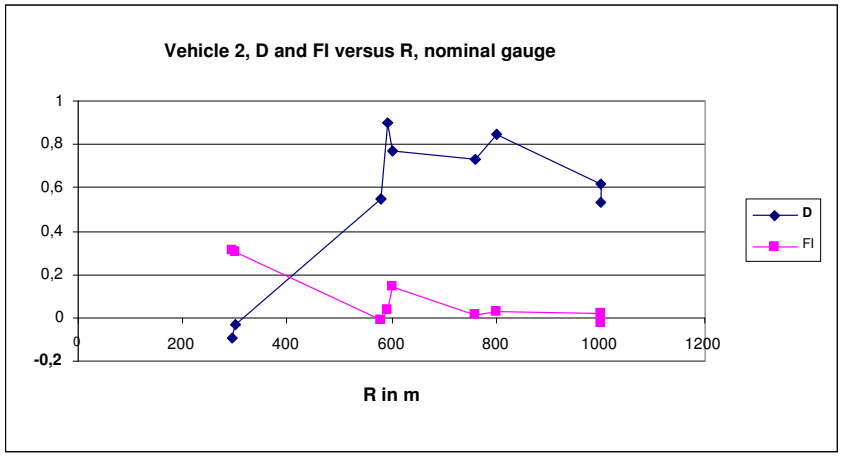
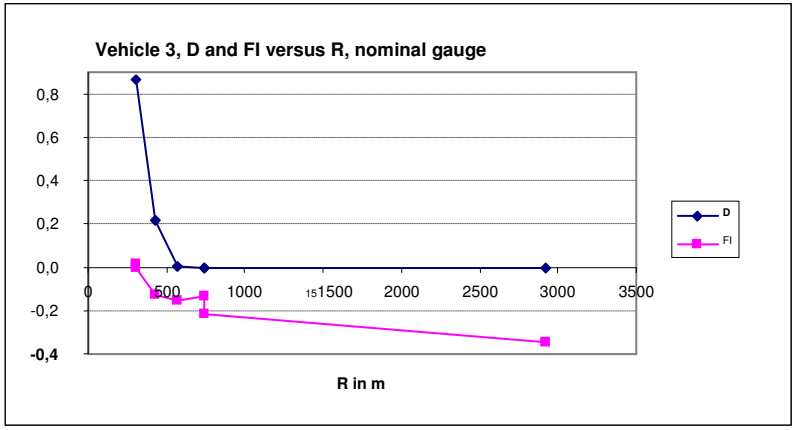
Evaluation with damage parameter

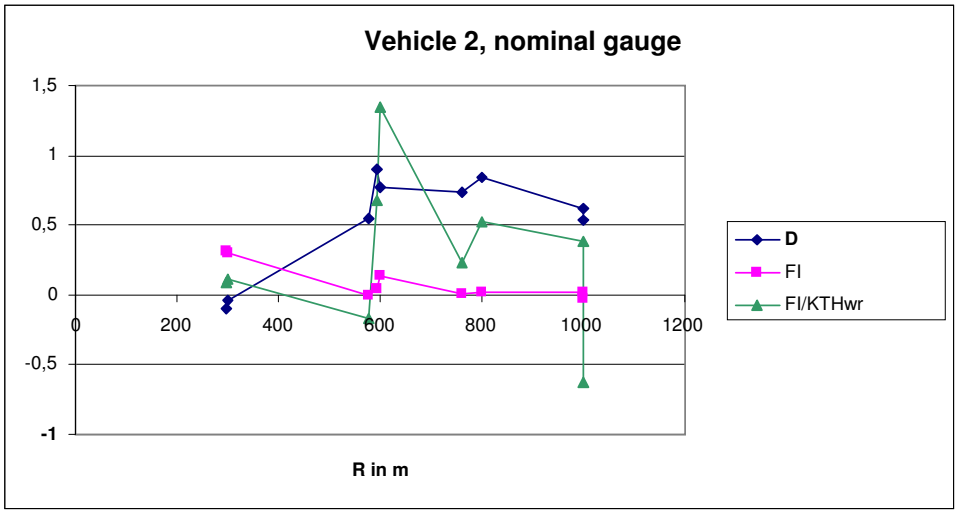


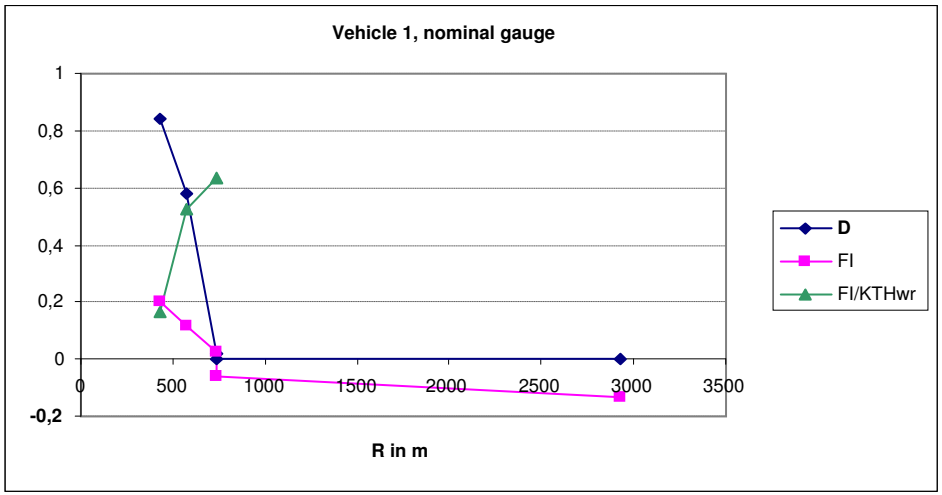




- Also the damage function produces results that correlate to the real behaviour of the wheels.
- The damage function seems to predict too much damage for vehicle 2 or too little damage for vehicle 1.

KTH wear measure

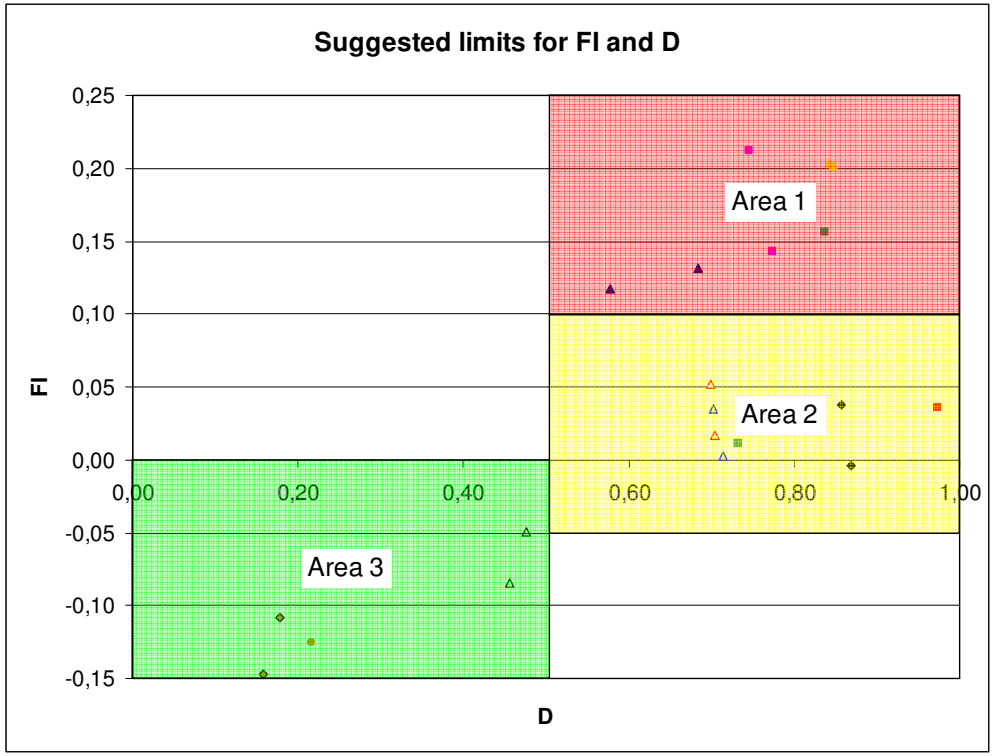




Wear measure:
FI / Wear volume

Wear model developed by
Enblom, Jendel
KTH Rail Vehicles

Guideline for assessment



Area 1 High risk for RCF
A minor portion of the operation in this area will lead to RCF damages.

Area 2 Risk for RCF
A larger portion of the operation in this area will lead to RCF damages.

Area 3 Low risk for RCF
A significant portion of the operation in this area may lead to RCF damages.

Conclusions

- Both the shakedown theory and the damage function can be used for indicative predictions using quasistatic simulations.
- It seems that the damage function is having a slightly better correlation to the experiences of RCF.
- The study indicates that the contact pressure may not be decisive for the onset of RCF considering the results for vehicle 1/S1002, i.e. high damage values and low FI. This is in line with the experiences from the UK rail study.
- The evaluation of the FI/KTHwear measure shows that it can be very sensitive to small variations in contact pressure. It is likely that this sensitivity will decrease if applying it to transient simulations with track irregularities due to average effects.

Further work

- Analyze more vehicles in order to improve the validation.
- Develop an evaluation method able to accumulate damage at different positions on the tread during transient simulations with track irregularities.
- Define a methodology to accumulate damage considering both the curve and gauge distribution.
- Implement braking forces in the simulations.