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Integrated simulation of damage: efficient contact modeling, wear-RCF interaction, and long-term evolution

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Key activities:

• Research and postgraduate education
• Graduate education
• Courses for professional engineers
• Seminars
• Consulting engineers
KTH Railway Group

Traffic and Logistics

Eskilstuna-Stockholm

Flemingsberg

Södertälje syd

Nykvarn

Läggesta

Malmby

Grundbro

Läggesta

Nykvärn

Malmby

Strängnäs

Härad

Kulla

Eskilstuna C

43

98

90

83

80

75

67

50

36

15

115

105

Cost effective bridges

soil-steel composite railway bridges

Electric Energy Conversion

Structural Engineering and Bridges

Machine design

Rail Vehicles

(Light and with good dynamic and acoustic comfort)

Wear and RCF
Wheel and rail damage simulation at KTH
Wheel and rail damage simulation at KTH
Multiscale analysis

- Contact Patch Modelling
  - Wear/RCF interaction
  - Wear prediction
  - RCF prediction

Large scale

Vehicle Dynamics

Small scale

SNCF

1mm (initial crack)
max \Delta k^2 (9.1)
17.8 \times 10^6 cycles
max da/dN (9.1)
18.10^6 cycles
Wheel and rail damage simulation at KTH

- Multiscale analysis
- Vehicle Dynamics
- Wear/RCF interaction
- Contact Patch Modelling
Contact patch modelling

Important for precise damage calculation

Hertz+FASTSIM

CONTACT code (most precise)

~ 0.02 second

~ 20 seconds
Creep Force

Pure translational case

\[-v_y = -u_y\]

**FASTSIM:**


ANALYN+FaStrip

\( \varphi = 0.05 \text{ l/m} \)

\( \nu_x = 0.5\% \)

- Hertz+FASTSIM
- ANALYN+FaStrip
- CONTACT

- Longitudinal x-coord. [mm]
- Lateral y-coord. [mm]
- Shear stress [MPa]

\( y = 0 \text{ mm} \)

\( y = -11 \text{ mm} \)
Results

Hertz+FASTSIM

ANALYN+FaStrip

CONTACT code

~ 0.02 second

~ 0.12 second

~ 20 seconds
Energy index in the patch
Wheel and rail damage simulation at KTH
Basic damage prediction modelling

**Wear**
- Initial wheel profile
- Contact data generation
- Transient simulations
- Wear calculation
- Scaling to step limit
- Wheel profile updating

**RCF**
- Metro wheels
- Tram rails
- Commuter wheels
- Freight wagon wheels
- Freight loco wheels
- Traction and braking
- Lubrication
- Friction coefficient
- Track irregularities
- …
Damage prediction modelling application


Wear-RCF interaction

Crack growth model + Archard

Validation – Wear

\[ t_f = \text{flange thickness} \]
\[ h_f = \text{flange height} \]
\[ q_r = \text{flange inclination} \]
\[ \Delta A = \text{worn-off area} \]

- \( o \) = measurements
- \( = \) simulation

Running circle

\[ h_f \]
\[ q_r \]
\[ t_f \]
Validation – Crack growth

\[ S I \]

\[ E I \]

\( c_{pe} = \) predicted crack length, wear excluded
\( c_{pi} = \) predicted crack length, wear included
\( c_{m} = \) measured crack length
Wear-RCF interaction

Surface Fatigue Index + Archard

Wear-RCF interaction
Validation – Long Term Development

Lubricated

Non-Lubricated

Running Distance (km)

Lateral Position of the Wheel (mm)

Accumulated RCF
Validation – Long Term Development

Bombardier Transportation
Wheel and rail damage simulation at KTH

Multiscale analysis

- Uniform wheel wear development
- RCF long term development

Vehicle Dynamics

- Subsurface fatigue
- Surface Fatigue + Archard
- Crack growth + Archard
- Lubrication tribology
- Improved wear maps

Contact Patch Modelling

- Normal contact
- Tangential contact

Wear/RCF interaction

- Software homogenization
- Statistical wear calculation

MBS coding
Applied in EU projects

Ongoing

Roll2Rail

C4R

Finished (selection)

SUSTRAIL

marathon

TrainDyna

VEL-Wagon

TOSCA

Thanks for your time!
Questions?

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