Innovative concepts and designs for resilient S&Cs

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Introduction

• C4R WP13 second task: “Resilient S&C” D132
  – Objectives:
    • Collect and organise relevant information on S&C related failure modes, based on the expertise available within the consortium and outside where possible (D131)
    • Propose innovative design to minimize material deterioration and failures
    • Suggest innovative design and operational practices to ensure resilience to extreme weather conditions
    • Survey optimized sensor strategies

• Minimizing S&C loads and deterioration
  – Short-term solutions
  – Middle-term solutions
  – Long-term solutions

• Resilience to extreme weather condition
  – Failure catalogue

• Sensor strategy
Failure catalogue

1.2 Rails

1.2.2 SHELLING

(Possible) Causes:
- High contact stresses leading to sub-surface or near surface cracks that merge together to cause localised loss of structural integrity that results in spalling/shelling of the material.
- Cracks due to Rolling Contact Fatigue (RCF), which are not removed before they merge.
- Previous weld repair was executed incorrectly.
- Crossings: High dynamic forces, lack of maintenance (grinding).

Characteristics: Running surface: small crack in the outer face of the rail head (few mm below running surface). At a later stage, a piece of the metal may break or peel away. Gauge corner: long dark spots randomly spaced out over the gauge corner of the merger of such cracks leading to localised loss of structural integrity and peeling/shelling of the surface material in the gauge corner which can sometimes be quite extensive.

Preventive/corrective measures:
Repair by resurfacing or repair welding.
Replacement of rail.

Detection:
Can be detected by ultrasonic testing.
Short term solutions
Modelling – switch panel

• Minimizing the effect of high lateral and longitudinal force

• Predicting the effect of design changes in the switch panels
  – Switch and stock rail design changes (cutting angles, nominal and
gauge widening, rail profiles, rail inclination...)
  – Improvement of material grades
  – Friction management
  – Output cumulative contact band
    and cumulative damage estimates for:
    • Wear
    • RCF
Material influence

Wear: 20-40% for R350HT compared to R260
RCF: 30-50% for R350HT compared to R260

Less wear in laboratory test (INNOTRACK)
Rail profile optimisation

Ty – Energy function for RCF initiation

Diverging route, facing move, 70 km/h, $\mu = 0.3$

Contact point top

Contact point side
Medium term solutions

Crossing panel

- Nominal
- Worn
- Hollow
Medium term solutions
Crossing panel

Wheels vertical motion

Vertical contact Force

Nominal  Worn  Hollow

Unfiltered Max(Q_{dyn}) - facing

120 km/h
40 km/h
Medium term solutions
Crossing panel

T→ left rail - C4R freight laden cen56fc v005 P10 dyn mat

T→ right rail - C4R freight laden cen56fc v005 P10 dyn mat

Peak RCF
Grade 250

Peak RCF
Grade 350

T_{1\max} = 40.1N
T_{2\max} = 36.3N
Medium term solutions
Crossing panel

Load vectors showing high magnitude sustained load (P2)
=> leading to component/ballast fatigue

Load vectors showing high intensity initial impact load (P1)
=> leading to local rail damage

Wheel-rail contact location showing intensity of loading

Vertical Force Gradient shown on contact location [kN]

0  50  100  150  200  250  300
0  30.5  31  31.5
Medium term solutions
Crossing panel

Ballast force at sleeper number = 13

- $K_{pad} = 130$ MN/m with USP
- $K_{pad} = 200$ MN/m
- $K_{pad} = 130$ MN/m

Distance [m]

Force [kN]
Long term solutions

New design
Improved material
Enhanced control and monitoring
Better maintainability

A concept based on continuous support for turnouts is proposed by Vossloh Cogifer. This concept is based on two principles:
Modular design
Continuous support
Resilience to Extreme Weather Situations

Winter
Summer

Buckling within S&C
Caused by:
• Extreme positive temperature gradients - rail expansion
• Insufficient lateral resistance

Preventative measure:
• Proper stress compensation done at assembly and welding.
• Stress redistribution after the S&C is set in operation (according to the real temperature range in the rail)

Longitudinal stresses give increased probability of buckling and will also affect the longitudinal position of the switch blade

Inside the S&C some forces also comes from diverging track

Rain
Desert condition
Sensor technology
Thank you for your kind attention

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Medium term solutions
Crossing panel

Wheelset lateral motion

LATERAL DISPLACEMENT - C4R freight laden cen56fc v005

Lateral contact Force

LATERAL FORCE - right rail - C4R freight laden cen56fc v005

Nominal
Worn
Hollow
Medium term solutions
Crossing panel

Cumulative contact band viewed from the top – opposite rail

Cumulative contact band viewed from the top – crossing rails

Wing
Nose