Corrective and Preventative Rail Maintenance by Grinding – Competing or Complementing Activities?

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* Definitions: Corrective / Preventive Grinding
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Rail Maintenance 1980

Longitudinal profile correction

Short pitch corrugation

Short waves
State of The Art

High production rates - working speed 3 – 16 km/h
Few grinding passes

Switches and Crossings
Corrugation

Short Pitch

Short Waves
Surface Damage (e.g. Object Imprints)
Objectives of Corrective Grinding

Removal of (severe) defects such as:

- Corrugation
- Plastic deformation
- Surface damage
- Surface fatigue

Restoration of optimal conditions
Gauge Corner Fatigue (Head Checks)
Objective of Cyclical Grinding

Repeated removal of top surface layer, minor correction of transverse profile

Removal / reduction of surface fatigue, maintaining optimal contact conditions

Intervention cycle depending on damage development
(mainly experience, in future recordings)
(e.g. 15 – 150 MGT, 0.1 – 0.3 mm metal removal at center)
Definition of Maintenance Strategies

- Corrective grinding
- Reactive grinding (Thresholds)
- Cyclical grinding
- Preventive grinding
- Initial (new rails) & Tonnage based
- Cyclical grinding
Initial Grinding Followed by Preventive Actions

Defect development

RCF Damage classes

Severe

Medium

Light

Good

Initial grinding

Cyclic Grinding

Source: ProRail

Tonnage
Effectivity of Complete Plus Cyclic Grinding

Defect development

RCF Damage classes

- severe
- medium
- light
- good

Tonnage

Complete Corrective Grinding

Cyclic Grinding

Source: ProRail
Effectivity of Incomplete Corrective Grinding

Defect development

- Severe
- Medium
- Light
- Good

Small effect of cyclic Grinding

Incomplete Corrective Grinding

Cyclic Grinding

Source: ProRail

Tonnage
Keeping rails free of surface defects:
    Optimized grinding programs
    Few grinding passes / One-pass-operation
    Rails (profiles) always in good shape

Overall constant conditions:
    Track conditions (radius, cant, elasticity)
    Traffic / operational conditions (speed, accelerations)
    Defect type and development
Practice – Defect Development

• Locally more severe defects / bigger than expected
• Changing position of defects (Surface cracks towards the center of the rail head)
• Unexpected defects (Squats, Studs, Spalling, ….. )
• Partially treated defects (initial, preventive) develop differently - Need for different metal removal rates
Practice – Execution

Organizational / logistic problems:

Traffic and site situation overruns planned schedule
Actual vs. expected conditions
Not enough time for last pass (production / finishing)

Disruption of cyclic grinding plan:
(Change of maintenance plans, track and traffic conditions)

Machine break-down ( ? )
Rolling Contact Fatigue (RCF)
Severe Rolling Contact Fatigue
*Unexpected Developments*

Example – Surprise Before Grinding
Example - Surprise During Grinding

After 8 grinding passes
Example – Surprise After Grinding
Occasional Criticism & Proposed Solutions

- (Steel grade selection and use -“no-wear-regime”)
  - (Special specs: target profile – tolerances – finish?)
- Inappropriate target profiles / tolerances
  - Change contact conditions / target profile
- Too “aggressive” grinding finish
  - Provide adequate finishing conditions

Avoid incomplete corrective work / partial defect removal
Head Checks Study (DB AG)
Head Checks – Study – Transverse Cut

HC – GRINDING (DB AG - Laboratory investigation)
Head Checks – Study – Longitudinal Cut

HC – GRINDING (DB AG - Laboratory investigation)
Squat - Principle

Longitudinal cut

Risk of branching/ turning downwards

First phase

~ 0.5 mm
Heavy Corrective Grinding Test
Heavy Corrective Grinding Test - Planning

Detected damage:
6 mm defect depth (US)

Request:
No profile change during work in area -70° to +5°!

RR 64 M-2 grinder

Calculation:
0.5 mm removal at 5 km/h

Plan: 12 passes

MiniProf measurements (4 locations):
> 0.5 mm per pass

Manual ET-checks,
Final US-check:
No defects remaining
Transverse Profiles – First Passes

Profile plot km 146.0568 low A

Passes 0 - 9

0.00
5.00
10.00
15.00
20.00
Situation After 7 Passes
Situation After 11 Passes
Examples – Last Passes

Profile plot km 146.0568 low B   Passes 0, 9 – 12, 14

-0.00
-0.12
-0.19
-0.11
-0.17
-0.13

0.00
5.00
10.00
15.00
20.00
Finished Ground Rail
Example of Finish Conditions
Heavy Corrective Grinding Test - Results

All defects completely removed!

Noise sensitive area:
2 additional finishing passes (at 16 km/h)

Measured roughness: $R_a$ (EN13231-3): < 4 microns

Production rate:
400 m of track / hour: > 6 mm metal removal

Remaining service life / corrective work vs changing rails!
Summarizing Remarks

1) Rail maintenance:
   Preventive cyclic grinding + Corrective work

2) In-track tests:
   Feasibility of heavy corrective grinding
   Successful defect elimination (Squats and Studs) with standard grinding equipment

3) Flexible planning with standard equipment
   Precise preparation work – valuable planning tool
   Postponing changing of rails
Examples of Machine Capacity

One-pass-grinding (cyclic – preventive) 0.3mm metal removal:

- 2 x RR 48  1 pass  7400 m finished / h
- (1 x RR 48  2 passes  3600 m finished / h)
- 1 x RR 64  1 pass  5900 m finished / h

According to defect depths:

Heavy corrective grinding > 6 mm metal removal
Pre-programming of pattern (speed / pressure) required

- 1 x RR 64  12 passes  400 m finished / h
Conclusions

- Preventive grinding assures generally good rail surface conditions
- Supervision is required to check the results
- Cyclic grinding with only partial damage removal may mask deeper damage (until spalling occurs)
- Local defect development needs to be addressed
- Corrective grinding complements preventive work
  - preceding preventive work
  - addressing specific damage development
Corrective and Preventative Rail Maintenance by Grinding

Competing or Complementing Activities?

THANK YOU FOR YOUR LISTENING