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Bevan, Adam and Molyneux-Berry, Paul

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Optimisation of Wheelset Maintenance – Current Research Activities

Modern Railways
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Paul Molyneux-Berry, Adam Bevan
Institute of Railway Research, University of Huddersfield
Background

• Wheelsets are expensive:
  – Manufacturing
  – Reprofiling
  – Inspections
  – Renewal
  – Environmental impact
  – Costs of trains out of service

• Strong demand to reduce the rate of wheel damage
  – Extend wheel reprofiling intervals
  – Better wheelset life
  – Lower costs
Wheelset Research

• Research projects relating to wheelset damage and maintenance practices include:
  – Influence of changes in material properties on observed damage
  – Optimisation of wheelset maintenance to reduce whole-system costs
  – Investigating the influence of route and vehicle design and maintenance policy on wheel tread damage
  – Assessment of alternative wheel profiles, considering both whole-system costs and running safety
  – Categorisation of wheel damage mechanisms to improve identification and selection of appropriate mitigation

• This presentation provides an overview of some of these research areas
Survey of Wheel Tread Damage

- Wide-ranging survey of wheel tread damage types and maintenance practices undertaken in-collaboration with RSSB, WMG, V/T SIC and ATOC
- Questionnaire review on passenger fleets
  - Wheel tread damage
  - Wheelset maintenance
  - Excellent response, >90\% of all UK passenger vehicles
- Follow-up visits/calls to depots and wheel lathes
  - Detailed discussions and observations of damaged wheels
- Collate and analyse responses
  - Fed back to check data and identify any inconsistencies
- ‘Workshops’ held at maintenance depots
  - Presented results
  - Further discussions and feedback
Reprofiling Intervals

![Diagram showing percentage of fleets in mileage range vs. average mileage between wheel reprofiling for different categories such as Tread-braked, Regional DMU, Intercity DMU, Commuter DMU, and different types of EMUs.]  

- Tread-braked
- Regional DMU
- Intercity DMU
- Commuter DMU
- Intercity EMU
- Locos
- Coaches

The x-axis represents the average mileage between wheel reprofiling, while the y-axis shows the percentage of fleets in a mileage range.
Reprofiling Intervals

• Typical wheelset reprofiled 3 or 4 times
  – Depends on damage type and depth
  – Scheduled at a distance interval, or based on condition monitoring
  – Wheelset renewed at minimum diameter
  – Average reprofiling interval is a good indicator of wheel life

• Longest fleet-average interval ≈ 10× shortest

• Intercity trains generally better than commuter trains
  – Operating conditions (speed, curve distribution)
  – Wheel materials

• Older tread-braked trains are worst

• Potential for costs savings and improved fleet availability
Example EMU Wheel Life

- Similar train architecture – various route characteristics and maintenance practices/constraints
Interaction of Wear and Damage

- Following initial flange wear - depth of cut on the lathe to restore the profile shape remains constant
- RCF cracks propagate more rapidly as the mileage increases
- Deeper cut required to remove RCF damage at higher mileages
- Optimum turning interval exists where material removal to restore profile shape is the same as required to remove RCF damage
Cut Depth to Recover Flange Wear

- Example radial material loss during turning to recover profile shape

Running Distance – 61,000 mile
0.6mm diameter loss due to wear
2.5mm cut depth to restore profile

Running Distance – 178,000 mile
2.0mm diameter loss due to wear
2.7mm cut depth to restore profile
Wheelset Maintenance Costs

• Important to understand potential costs and savings from implementing measures to extend wheelset life
• Knowledge of the dominant damage mechanisms, constraints and costs are essential for identifying benefits and cost impact
• Tools such as RSSB/NR’s *Wheelset Management Model (VTISM)* can help to support a business case
Categorisation of Damage

- RSSB research project T963 developed a *Wheel Tread Damage Guide*

- This guide provides:
  - Common basis for categorising wheel tread damage
  - Information on causes and mechanisms of wheel tread damage
  - Methods for managing wheel damage, maximising life and minimising costs
  - Industry case studies
Observations

• Route characteristics and maintenance practices have a large influence on wheelset life
  – In some cases more significant than the design parameters of the train

• Maintenance constraints resulting from design aspects are also important
  – e.g. bearing life, bogie overhaul periodicity and parity limits

• Maintainers who keep detailed wheel condition and maintenance records, managed and optimised their practices, achieved much better wheel life than those who did not
Reprofiling may be scheduled on a regular-interval preventive basis, or using condition monitoring techniques:
- Both methods can be effective
- Mileage-based reprofiling tends to be carried out more frequently, but may remove less material on the lathe

Obvious ‘quick wins’ could give good financial return:
- Solving WSP problems to prevent flats
- Provision of effective flange lubrication
- Best practice at the wheel lathe to optimise cut depths

With flats and flange wear solved, RCF is often the limiting damage mechanism:
- Can be managed by preventive reprofiling at an optimised interval
- Can be reduced by the use of an alternative wheel profile, suspension characteristic or premium wheel steel
RCF Cracks in Wheels

- Many factors influence RCF crack growth rates in wheels
  - Material properties, train type, operating/environmental conditions, position of wheelset on train
- Research being conducted to investigate changes in material properties and residual stresses during the life of a wheel
- Neutron diffraction used to measure distribution of strains and stresses in 3 entire railway wheels
- Initial results suggest that stresses are redistributed within the wheel rim during its life as material is removed and plastic flow occurs
Conclusions

- Benefits of managing and analysing wheel condition and maintenance records have been demonstrated
  - Bringing together maintainers of similar fleets helped to share best practice
  - It is expected that wheelset life can be improved on many fleets, with resultant cost savings

- A guidance document for optimising wheelset life has been developed
  - To assist maintainers in categorising and reducing wheel damage
  - Available to RSSB members through SPARK
  - Some maintainers have incorporated this into their maintenance documentation

- Feedback is requested to support future development