A New Wheel Profile for North American Freight Railroads: AAR-2A

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Overview

• Background
  – Wheel/rail profiles, contact conditions, wear
  – Relevant history
• Development and design
• Modeling
• Testing
• Implementation
Wheel and Rail Profiles

- Safety/Guidance
- Performance
  - Wear
  - Surface damage
  - Train energy consumption
  - Vehicle and track maintenance

RCF & Shells
Conformality

- High rail contact condition
  - Flange contact, >2 deg curve
  - 2-point, conformal, 1-point

- Metrics
  - Maximum gap
  - Rolling radius difference
Wear

- Wheels and rails wear to a common conformal shape
- Majority of wheels and rails are worn
- Annual replacement rates:
  - About 10% wheels, 3% rail

Measured 2 to 6 degree high rails aligned at gage corner

4 Extremes of flange height and thickness aligned at flange root

122 measured wheelsets
AAR 1:20 Profile

- Pre-1990
- Improvement from cylindrical profiles
- 70 degree flange angle
- Flange fillet radius 0.75 inch
- 1:20 tread taper
AAR-1B Profile

- 1990 to current
- 75 degree flange angle
- Multiple flange fillet radii
- 1:20 tread taper
- Developed in 1980s from measured worn wheel profiles
AAR-1B Profile

• Original version called AAR-1 (1 of 4 candidate profiles)
  – 4 intersecting arcs in flange fillet, max radius 20 inches

• Simulation + Testing at TTC
  – Candidates showed improved curving performance and rolling resistance but lower hunting threshold than AAR 1:20
  – Hunting onset 49 mph for AAR-1 vs 70 mph for AAR 1:20

• Revised versions to improve stability called AAR-1A and AAR-1B

• Revenue service testing
  – Improvements in wear rate
AAR-2A Profile

- 2016 to ?
- 75 degree flange angle
- Multiple flange fillet radii
- 1:20 tread taper
- Developed in 2000s from measured worn wheel profiles
AAR-2A Profile

• Design based on analysis of 210 pairs of rail profiles and 122 wheelsets
  – Variety of wear levels, curvatures, car types

• Original version called TTCI-1A, then SRI-1A

• Final version includes a reduction in flange thickness of 1/8 inch
  – Improve high speed stability
  – Further improve curving performance

• Wide flange (new, 1.25 inch) and narrow flange (turned, 1.15 inch) versions of the AAR-2A profile available
Profile Overlay

Typical Worn High Rail

AAR 1:20

AAR-1B

AAR-2A
NUCARS® Simulation of AAR-2A

- Reduced angle of attack leads to reduced gage spread force
NUCARS® Simulation of AAR-2A

- Reduced wear and rolling contact fatigue
NUCARS® Simulation of AAR-2A

- High speed stability similar for worn AAR-1B and worn AAR-2A
  - Measured track geometry and relatively flat rail profile
AAR-2A Profile Test #1

• One 5-unit articulated double stack car

• Wheel wear and gage spread force benefits

• Hunting
  – None from 109 wayside passes
  – 1 brief instance measured on-board (original thicker flange version of profile)
AAR-2A Profile Test #2

- 10 coal cars
- Gage spread force benefits noted up to 25,000 miles of service
AAR-2A Profile Test #3

- 200 grain hoppers, 2 RRs, final version of profile
- Wear benefits at 115,000 miles
  - 40% less tread wear
  - Lower wear rate for flange thickness
  - Less hollowing and asymmetric wear
  - Flange root shape
AAR-2A Profile Test #3

- Wheelset survival + hunting results
Conclusions

• AAR-2A designed to be nearly conformal with typical high rail
  – Flange root shape based on measured worn wheels
  – Rolling resistance, wear, fuel consumption, surface damage
• 75 degree flange angle, 1:20 tread taper
• Development similarities to predecessor (AAR-1B)
• Analysis, simulation, testing show benefits
• AAR currently allows AAR-2A as alternate standard for turned wheels; will begin transition to AAR-2A for new wheels in 2018