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Asymmetric Flange Wear: Possible Root Causes & Remedies

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Summary

Transportation Technology Center, Inc. (TTCI) has further investigated the phenomenon of asymmetric wheel flange wear (AWFW) on a series of 134 coal cars. In this *Technology Digest* (TD), four hypotheses are presented as to the possible root causes for AWFW and the results from brake shoe dynamometer tests have been examined. It is concluded that AWFW results from a combination of:

- Asymmetric truck rigging topology
- Abrasive brake shoes
- Excessive lateral clearance between shoe and wheel associated with a combination of, brake rigging topology, brake beam, brake shoe, and truck dimensions and tolerances

These lead to asymmetric wheel tread wear, which leads to:

- Poor vehicle tracking on tangent and curved track results in flange contact
- Flange contact results in accelerated wheel flange wear
- Wheel flange wear increases the lateral clearance between shoe and wheel, which exacerbates the flange wear cycle

This TD is the last of three TDs relating to the AWFW performance observed on this series of coals cars. The other two TDs describe:

- The results of an analysis of maintenance data of the specific car fleet
- The results of in-service inspections of a number of cars and teardown inspections of two cars conducted at the Transportation Technology Center

A TD suggesting an improved brake shoe shape, another TD suggesting that shoe wear may be the cause of tread wear resulting in high contact conicities, and a further TD suggesting that AWFW is a generic problem to the North American car fleet will follow this TD.

TTCI was tasked to support the Advanced Technology Safety Initiative (ATSI) through the Association of American Railroads' (AAR) Strategic Research Initiatives (SRI) Program. Car owners identified the AWFW problem and requested ATSI to investigate it. TTCI was also tasked under the AAR SRI Program to develop design concepts for an integrated freight car truck (IFCT). IFCT design concepts will include means to address the problem of AWFW.

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INTRODUCTION

An increased incidence of wheel flange wear has recently been reported by a number of car owners and, in particular by Mitsui Rail Capital.[1] TTCI has been tasked to investigate this phenomenon through the AAR SRI Program.

Analysis of wheel repair data on a selected series of 134 coal hopper cars owned by Mitsui Rail Capital[1] suggests that the observed wheel wear is asymmetric (one wheel flange on a wheelset wearing to the condemning limit while the opposing flange on the wheelset remains substantially unworn). In addition, the flange wear takes place on diagonally opposing wheels in a truck.

Findings to date[2] suggest:

- Asymmetric flange wear occurs in a predominantly diagonal sense across the wheels of trucks and in relation to the A- and B-ends of the cars in the fleet.[1]
- This wear appears to be associated with:[2]
  - The asymmetric topology of the brake rigging
  - The lateral migration of the brake beams of a truck in opposite senses as a consequence of rigging asymmetry
  - Asymmetric tread wear on wheels on the same wheelset; this wear being associated with the action of the brake shoe on the wheel tread

To rule out other possible root causes and whether the abrasive action of brake shoes is sufficiently significant to influence AWFW, four possible hypotheses have been developed and evaluated, an attempt has been made to quantify the abrasiveness of certain brake shoes, and the root cause for AWFW has been more clearly defined.

Investigations and further analyses into the root causes for abnormal wheel flange wear in general, and AWFW in particular, continue and are reported in forthcoming TDs together with suggested remedies.

POSSIBLE ROOT CAUSES FOR ASYMMETRIC FLANGE WEAR

Four possible root causes for AWFW have been proposed:

i. A bias in the sense of curves negotiated by the cars:

A diagonal wheel flange wear pattern similar to that observed through the maintenance data[1] and teardown inspection observations[2] can occur in cars negotiating tight curves in a counterclockwise sense, both with the A- and B-ends of the cars leading. This can occur on balloon tracks located at loading and off-loading sites (Figure 1).

The operational history of the car series was investigated and the incidence of clockwise versus counterclockwise negotiation of the loading and off-loading balloons was noted.

Operating records for these cars show that:

Clockwise passes, loading:	175
Counterclockwise passes, loading:	92
Clockwise passes, off-loading:	all
Clockwise passes versus counterclockwise:	83%

A dominantly clockwise loading and off-loading sense as observed above would imply that the opposing flanges to those observed would have to wear. Consequently, it was concluded that the wheelsets were not being asymmetrically worn through a bias in the sense of curves negotiated.

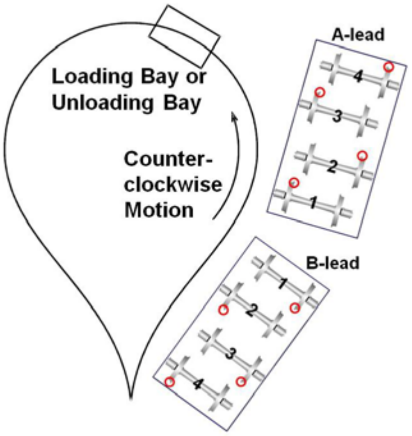

Figure 1. Typical Balloon Track Configuration

ii. Asymmetric tread wear as a consequence of asymmetric brake shoe contact:

The observed differences in tread wear between wheel profiles with and without tread wear[2] suggest aggressive wheel wear due to the action of the brake shoes, with the brake shoe rapidly migrating laterally across the tread as the flange wears (Figure 2).

Figure 2. Wheel/Rail Contact Conditions Resulting from Asymmetric Wheel Tread Wear

Asymmetric wheel tread wear can destroy the ability of the wheelset to negotiate tangent track without flange contact with the gage corner of the rail. Then, the loss of steering ability may result directly in flange contact and with a wheelset angle of attack and consequent flange wear. Extended flange contact with the gage corner of the rail on tangent track is known to be the source of extremely aggressive and rapid flange wear, resulting in drastically reduced wheel flange lives.

Asymmetric wheel tread wear need not commence immediately; it might commence only after the wheel flanges have worn symmetrically, increasing the lateral free play between brake shoes/brake beam and wheel. Asymmetric forces on the brake beam from the brake rigging asymmetry, combined with this free play, will result in the brake shoe/brake beam favoring contact against one wheel flange.

iii. *Asymmetric flange wear as a consequence of asymmetric brake shoe contact with the flange:*

The action of a brake shoe bearing against one flange as shown in Figure 3 might:

- Scour that flange of any lubricant picked up at rail flange lubricators
- Heat the contacting flange to temperatures in excess of 900°F;[3] which might result in no adherence of the flange/rail lubricant, because the viscosity of the lubricant can be severely reduced above 200°F

Both of the above might result in differential flange wear because the flange of the opposing wheel of the wheelset may be proportionately better lubricated.

Figure 3. Brake Shoe Contact on One Flange

The scrubbing action of the shoe on the wheel flange might directly abrade the flange and be the root cause for the flange wear.

Then, asymmetric flange wear might generate asymmetric tread wear as the wheelset negotiates tight curves. A combination of asymmetric flange and tread wear may accelerate asymmetric flange wear to condemning limits.

iv. *Asymmetric flange wear as a consequence of the combined action of asymmetric tread wear (ii) and asymmetric flange contact (iii):*

A combination of the abovementioned two effects may obviously also occur.

BRAKE SHOE ABRASIVENESS

The hypotheses posed in *ii*. to *iv*. suggest that an indication of the degree of abrasiveness of the brake shoes should be found. The AAR conducts regular certification and recertification of brake shoes on a brake dynamometer. The reduction in thickness of the brake shoe during the tests and the resulting wear on the dynamometer wheel are recorded. There is a large variation in performance in brake shoe/dynamometer wheel wear depending on brake shoe type. However, to obtain an indication of the maximum degree of brake shoe abrasiveness, the results from a series of tests on one particular brake shoe were used:

- Average reduction in brake shoe thickness during the test is:
  0.02 inch
- "Usable" thickness of a 1.5 inch brake shoe is:
  1.5-0.375 = 1.125 inch
- Consequently, brake shoe life is equivalent to:
  1.125/0.02 = 56 test cycles
- Average maximum tread wear during one test cycle:
  6.9/1,000 = 0.0069 inch
- Consequently, during the life of a 1.5-inch brake shoe, the wheel tread will wear at its deepest by:
  (6.9/1,000) x 56 = 0.386 inch

Figure 4 shows the typical form of the tread wear measured.

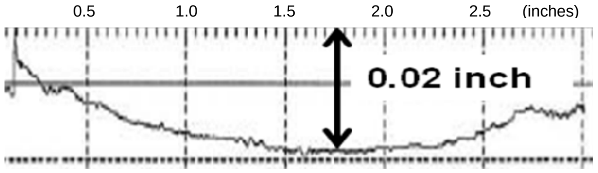

Figure 4. A Hollow Wear Pattern Produced by a Brake Shoe on a Cylindrical Dynamometer Wheel Tread

The maximum wear is at the center of contact, gradually decreasing as contact with the brake shoe is made. This type of wear would be difficult to distinguish from rail/wheel contact, but it is made on the field side of the wheel tread as detected from wheel profile measurements on selected cars. It is of the same order of magnitude as the observed wear of 0.1 inch on the field side of the measured asymmetrically worn wheel profiles.[2] This latter observation:

- Is associated with contact on the edge of the brake shoe
- Does not account for the speed of lateral migration of the brake shoe across the tread

Therefore, no further attempt at accurate comparison is made.

If applied asymmetrically to the wheel tread, this amount of wear will have a significant impact on the steering properties of the wheelset on tangent track with consequential wheel wear. It is difficult, however, to envisage at the wear rates observed under test that the direct action of the shoe on the flange would cause the rate of wheel flange wear observed.

BRAKE SHOE/WHEEL_TREAD CONTACT

The width of a brake shoe is not accurately specified; the nominal width of the backing plate is specified as 4 inches.[4] The transverse profile of the brake shoe is not defined; however, the width of one specific brake shoe was measured as approximately 3.4 inches, which is 0.6-inch narrower than the nominal width of the backing plate.

The nominal pitch and tolerance of the brake shoes across the brake beam is defined.[5]

Figure 5 shows the approximate nominal position of the brake shoe on the wheel tread for a 3.4-inch-wide brake shoe and a nominal brake beam length.

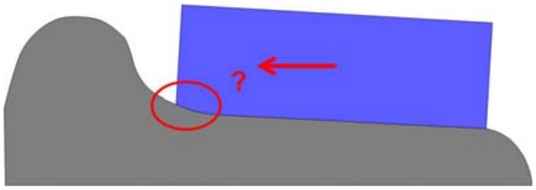

Figure 5. Nominal Position of a Brake Shoe on the Tread

The detail of the edge of the brake shoe in contact with the flange fillet is not known; however, certain brake shoes have a relief detail in this region. Figure 5 indicates:

- There is no definite lateral support for the brake shoe and brake beam if they are subjected to a lateral force. It ignores any support provided in the brake beam pocket of the side frame.
- There is a large lateral gap between brake shoe and flange, which with minimal lateral brake shoe wear can result in asymmetric contact unless constrained in the brake beam pocket.

As the wheel flange wears, unless constrained in the brake beam pocket, the degree of asymmetric contact increases so that as the flange approaches condemning limits contact with the tread of the wheel with the worn flange approximates Figure 6.

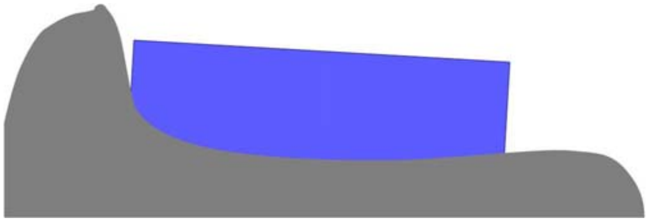

Figure 6. Brake Shoe Contact with Tread with Worn Flange

Figure 7 shows approximate brake shoe/tread contact on the opposite wheel.

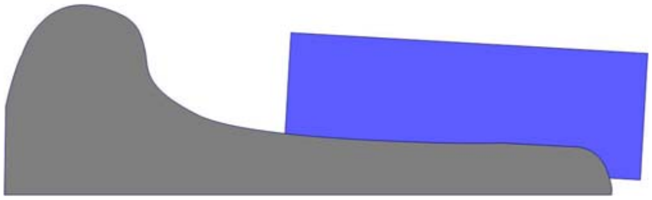

Figure 7. Brake Shoe Contact with Tread with Worn Flange

This is similar to a picture of observed overhanging brake shoes shown in Figure 3 in Reference 2.

CONCLUSIONS

The root cause for AWFW is one or a combination of:

- The asymmetric loading and location of the brake shoe on the wheel tread and flange, which is directly attributable to the design of the truck brake rigging and the connection between this rigging and that of the car.
- The large lateral clearance between the brake shoe and the flange resulting from:
  - A combination of current brake beam dimensions and tolerances and brake shoe width
  - Flange wear

  This clearance can result in asymmetric tread wear, exacerbated by abrasive brake shoes.

  Increased lateral clearance and the resulting lateral sense motion of the two brake shoe/brake beam assemblies in a truck:
  - Increases the angularity of the rod-through push rod which, in turn, increases the lateral component of the brake force on the flange
  - Results in overhanging brake shoes, which are associated with heat checks on wheels
- Care must be taken in relating the lateral clearances between brake shoe and wheel and those between brake beam and side frame. If both clearances are too tight, truck warp can induce jamming of the brake shoe against the flange and result in skidded wheels.

RECOMMENDATIONS AND FUTURE WORK

- Reduce the lateral clearance between brake shoe and flange to facilitate the guidance of the brake beam. This will reduce the incidence of asymmetric tread wear, the lateral forces on the wheel flange, and consequently, AWFW and overhanging brake shoes.
- Analyze the combined lateral clearances between brake shoe and flange and brake beam and side frame to ensure that no binding will occur between wheel and brake shoe under prevailing truck warp conditions. This analysis should account for the improved warp restraint of M-976 trucks as well as prevailing anti-warp capabilities of non-M-976 trucks. The effect of reduced clearance should be verified through controlled tests.
- Review the optimal width of the brake shoe in relation to the width of the wheel tread, the allowable flange wear, and the length of the brake beam length and associated tolerances.

ACKNOWLEDGEMENT

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