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Asymmetric Flange Wear: Inspection and Teardown Results

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Summary

Transportation Technology Center, Inc. (TTCI) has conducted inspections and teardowns of two cars from a fleet of 134 coal cars reported to be experiencing asymmetric wheel flange wear. These cars are from the same series whose maintenance performance was analyzed and reported previously.¹

Teardown results suggest that the observed asymmetric wheel flange wear on the wheelsets within the car may be associated with:

- Asymmetric topology of the brake rigging
- Lateral migration of the brake beams in a truck in opposite senses as a consequence of rigging asymmetry
- Asymmetric tread wear on wheels on the same wheelset, and this wear is associated with the action of the brake shoe on the wheel tread

There is some evidence of asymmetric wear patterns on truck suspension wedges, column wear liners, gibs, and pedestals. These wear patterns are considered to be a consequence of the asymmetric wear associated with the topology of the brake rigging and not the direct cause for asymmetric wheel flange wear.

This *Technology Digest* (TD) is the second in a series of three TDs relating to the wheel performance of this car series and investigating the root causes for the observed flange wear. The other two TDs report on:

- The results of an analysis of maintenance data of the specific car fleet: in which the phenomenon of asymmetric wheel flange wear was detected and the incidence of it is confirmed through the teardowns reported in this TD.
- Possible root cause for this wear and remedies: in which the abrasiveness of some brake shoe types is confirmed and asymmetric wheel flange wear is further associated with the dimensions of the brake shoe in combination with the brake beam.

Investigations continue into the root cause of asymmetric wheel flange wear, particularly in regard to asymmetric wheel flange wear in the North American car fleet in general, including the possible role of brake shoe abrasion on wheel tread wear. Results of these investigations are reported in further TDs.

TTCI has been tasked to support the Advanced Technology Safety Initiative (ATSI) through the Association of American Railroads' Strategic Research Initiatives Program. The asymmetric wear problem was identified by car owners who requested ATSI to investigate the asymmetric wheel flange wear problem.



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 Association of American Railroads’ (AAR) Strategic Research Initiatives Program.

Analysis of wheel repair data on a selected series of 134 coal hopper cars owned by Mitsui Rail Capital¹ suggests that the observed wheel wear is asymmetric (i.e., 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, as Figure 1 indicates.

In order to establish the root causes for this asymmetric wheel flange wear, TTCI conducted an inspection and teardown of one of the cars from this series and of one gondola coal car from a related series. Each series was equipped with M-976 trucks and otherwise identical brake rigging, etc. This TD reports on the results. The conclusions were identical for both car types inspected. A third TD will describe hypotheses made as to the root cause for the wheel flange wear.

Future TDs will report on further investigations and analyses into the root causes for abnormal wheel flange wear in general, asymmetric wheel flange wear in particular, and remedies for this phenomenon.

INSPECTION AND TEARDOWN OBSERVATIONS

Observations from inspections and teardowns centered on three phenomena:

- The topology and service-worn orientation of the truck brake beams and rigging
- Wear patterns on truck suspension wedges, column wear liners, gibs, and pedestals
- The worn shapes of the wheel profiles

These findings are as follows:

Truck brake beams and rigging

The brake beams migrate in opposite lateral senses, as Figure 1 indicates, from a laterally central position in the truck when all components are new/replaced. The overriding brake shoe is pressed against the most worn flange (Figure 2 and circled flanges in Figure 1) and the overriding shoe contacts the opposite wheel having the least worn flange (Figure 3).

The truck brake rigging is of the rod-through type. Figure 4 indicates the orientation of the A-truck rigging in the same sense as the orientation of the A-truck in Figure 1. By inspection it may be seen that:

- The lateral reactions of the rod-through pushrod are in a sense to force the beams laterally into the opposing lateral senses observed on teardown
- The moment due to the non-co-linearity of the pull-rod and reaction link acts in a sense to move the truck rigging (and brake beams) in the same sense as observed on teardown

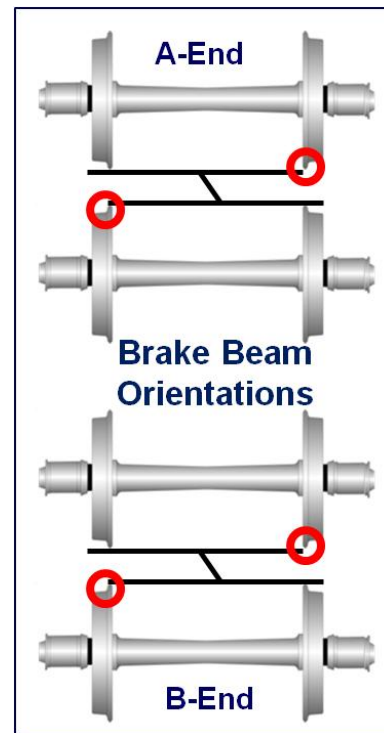


Figure 1. Opposing Lateral Sense of Brake Beams in the Car



Figure 2. Overriding Brake Shoe Pressing against Worn Flange



Figure 3. Overhanging Brake Shoe on Opposing Brake Beam/Wheel

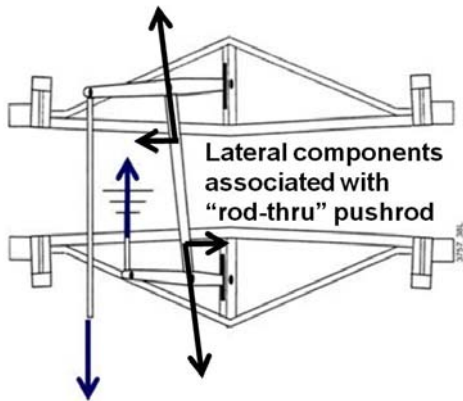


Figure 4. Rigging Topology of the A-Truck

Wear patterns on truck suspension wedges, column wear liners, gibs, and pedestals

Wear on the truck suspension wedges, column wear liners, gibs, and pedestals was found to be minimal and difficult to measure or quantify. There were indications of differential pressure across:

- Column wear liners (Figure 5)
- Bolster pockets (Figure 6)
- Gib surfaces on bolsters/side frames (Figure 7)



Figure 5. Indication of Uneven Pressure on Column Wear Liners



Figure 6. Indication of Uneven Wedge Pressures on the Truck Bolster

Similar indications were found within the pedestals and on the adapters.

These wear patterns suggest lateral forces acting on the wheelsets in the senses indicated by Figure 8.



Figure 7. Gib Clearance

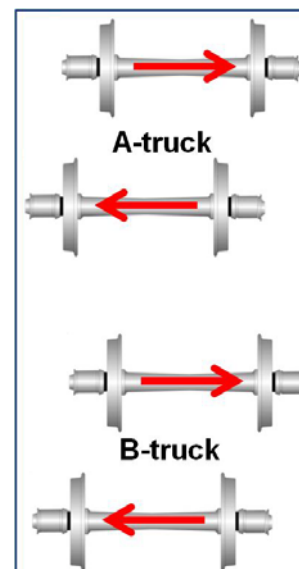


Figure 8. Sense of Truck Warp

These forces are in senses opposite to the brake beam migration observed and described earlier in this TD.

Worn Wheel Profiles

Miniprof™ measurements were taken of wheels from 15 cars in service. These profiles were of asymmetrically worn wheels on wheelsets with one wheel close to condemning for Why Made (WM) 60 code (thin flange). The asymmetrically worn wheels on the cars sent to TTC were not measured prior to being sent to Transportation Technology Center.

The profiles on wheels approaching condemning for AAR WM 60 code (thin flange) generally showed the same shapes, as Figure 9 indicates.



Figure 9. Miniprof Wheel Profiles Showing Asymmetric Wear

Analysis of these worn profiles shows:

- Differential wheel flange wear between wheels on the same wheelset (as expected)
- Differential and asymmetric tread wear; the wheel with the worn flange has greater tread wear closer to that flange

Consequently, when the wheelset contacts the rail on tangent track it must run in a laterally deflected position to generate equal rolling radii on each wheelset. The laterally deflected position requires near-flange contact of the worn wheel with the rail, as Figure 9 indicates. Consequently:

- Small dynamic excursions of the wheelset result in flange contact on tangent track. Because tangent track predominates, flange wear rates can be high under these conditions.
- There are differential curving forces in curves of different senses. Very high forces are generated in one sense resulting in high wear rates, and low forces are generated in the opposite curve sense.

Figure 10 shows the superposition of opposing wheel profiles on the same wheelset together with the original AAR-1B wide flange profile. The left- and right-hand asymmetrically worn wheel profiles and an unworn AAR-1B profile are vertically aligned at the flange tip to approximate their relative diameters.

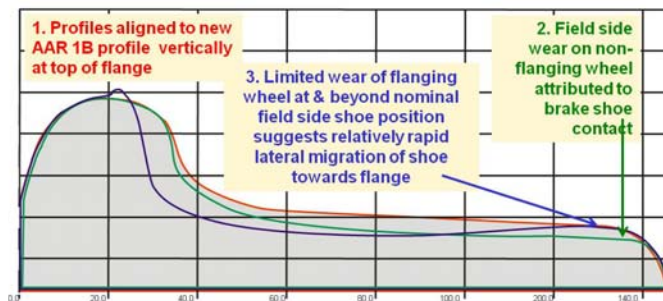


Figure 10. Comparison of measured profiles of opposing wheels on the same wheelset with the new AAR-1B profile

The asymmetry of the lateral location of the tread wear is evident. In addition, it would appear that the field side of the wheel with the relatively unworn flange has experienced appreciable tread wear. Little contact is made in this region between rail and wheel. This contact is limited to that made in switches and crossings and on the low rail of tight curves having gage at the limit of wide gage. Contact in this region is, however, made between the overhanging brake shoe and the wheel. Conversely, the wheel with the worn flange shows little field side tread wear and more wear closer to the flange; which could be associated with the contact of the overriding brake shoe on that wheel.

It would appear that during the life of the wheel profiles there is a rapid lateral migration of the brake shoe toward the flange of the wheel showing the greatest flange wear and away from the flange of the wheel with the least flange wear.

The sense of the lateral positions of the wheelsets required by the observed differential tread wear is identical to that shown by Figure 8 and:

- It is not in the sense suggested by the lateral migration of the brake beams observed on teardown and indicated by Figure 1
- It is in the same sense as the sense required by the observed differential wheel wear patterns as Figure 8 indicates

Finally, the differential wheel tread wear patterns observed and resulting in the lateral wheel positions indicated in Figure 8 may be the cause for the differential wear patterns on truck suspension wedges, column wear liners, gibs, and pedestals. These patterns are in accordance with a truck resisting the warp, which would be required of a truck to allow the wheelsets to attain the positions that Figure 8 indicates.

CONCLUSIONS

Asymmetric wheel flange wear appears to be associated with:

- The asymmetric design of the brake rigging causing:
- 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 is associated with the action of the brake shoe on the wheel tread

There is some evidence of asymmetric wear patterns on truck suspension wedges, column wear liners, gibs, and pedestals. These wear patterns are considered to be a consequence of the asymmetric wear associated with the topology of the brake rigging and not the direct cause for asymmetric wheel flange wear.

FUTURE WORK

It is recommended that the root causes for asymmetric wheel flange wear be further investigated, including:

- Verification of the abrasive action of the brake shoe on the wheel tread
- The elimination of other possible causes for asymmetric wheel flange wear
- An analysis of the dimensions and tolerances of the brake shoe, brake beam, wheelset, and truck assembly to establish a means to improve brake shoe guidance and centrality on the wheel tread

ACKNOWLEDGEMENTS

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REFERENCES

1. Tournay, Harry et al. October 2010. "Asymmetric Flange Wear: Data Analysis," *Technology Digest* TD-10-034, Association of American Railroads, Transportation Technology Center, Inc., Pueblo, Colo.

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