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Teardowns of Cars Identified by Optical Geometry Detectors

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Summary

Optical geometry detectors (OGD) are one type of detector under consideration for identifying cars in need of maintenance by the Mechanical and Vehicle Track Systems Research Committee. Transportation Technology Center, Inc. participated in the inspection and teardown of eight cars identified as poor performers by OGD. This *Technology Digest* describes repairs applied to each car and ensuing OGD data in the 14 to 18 months after the repairs. Conclusions from this work are as follows:

- OGDs are effective at identifying asymmetrically worn wheelsets based on their tracking position.
- Asymmetrically worn wheels will exhibit non-ideal tracking on tangent track regardless of the condition of the truck.
- Heavily worn trucks can lead to accelerated asymmetric wheel wear.
- Additional research relating the cause and effect relationships of cars identified by OGDs is needed. This research is planned for 2011 under the AAR Strategic Research Initiatives Program. Additional funding is provided by TTX and CSXT to accelerate the test program.

The lateral position of each passing wheelset relative to the track centerline and the angle of attack relative to the rail are determined by an OGD. Detector sites are located on tangent track and paired with automatic equipment identification readers to enable the matching of individual wheelsets with specific cars.

The transverse profile of the two wheels of a wheelset can have a large influence over the tracking position of that wheelset. Sometimes one wheel experiences significant wear in the flange and flange root while the mate wheel experiences wear primarily on the tread surface. This condition is called asymmetric wheel wear. Wheelsets with asymmetric wheel wear force themselves into a position with lateral displacement relative to the track centerline in order to produce equivalent rolling radii on each rail of the track.

The Association of American Railroads' Advanced Technology Safety Initiative research program is overseeing the work to determine the appropriate notification criteria and maintenance response to the data generated by certain wayside detectors.

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INTRODUCTION

The Association of American Railroads' (AAR) Advanced Technology Safety Initiative research program is overseeing the TTCI research to determine the appropriate alarm criteria and maintenance response to the data generated by certain wayside detectors. An OGD is one type of a detector under consideration by TTCI. This *Technology Digest* describes the inspection and teardown of eight cars identified as poor performers by OGDs. The repairs applied to each car and ensuing OGD data in the 14 to 18 months after the repairs are described.

BACKGROUND

The lateral position of each passing wheelset relative to the track centerline (known as Tracking Position) and the angle of attack relative to the rail are determined by an OGD. Sites are located on tangent track and paired with automatic equipment identification (AEI) readers to enable the matching of individual wheelsets with specific cars. The busiest OGD sites located on CSXT's lines record over 800,000 truck passes per month. CSXT has established internal logic for OGD alarms that require repeat exceptions above specified thresholds. For the geometry detectors, this requirement discriminates against selecting cars with truck hunting or other unique travel conditions that may cause a singular extreme measurement. The OGD used for selecting cars for this project was the TBOGI™ detector manufactured by Wayside Inspection Devices, Inc.

Truck-based metrics are created from the OGD measurements including the following:

- Shift – linear measurement indicative of both axles in a truck displaced laterally from the track centerline in the same direction; calculated by averaging the Tracking Position values from the leading and trailing axles; CSXT considers Shift values of 0.39 inch or greater as poor performance based on the distribution of shift values for all data:
    - 80 percent of Shift readings less than 0.20 inch
    - 17 percent of Shift readings 0.20-0.39 inch
    - 2.6 percent of Shift readings 0.39-0.59 inch
    - 0.4 percent of Shift readings greater than 0.59 inch
- Tracking Error (TE) – linear measurement indicative of both axles in a truck displaced laterally from the track centerline in opposite directions; calculated by subtracting the Tracking Position of trailing axle from the Tracking Position of the leading axle; CSXT considers TE values of 0.59 inch or greater as poor performance based on the distribution of TE values for all OGD data (tangent track):
    - 92 percent of TE readings less than 0.59 inch
    - 5.2 percent of TE readings 0.59-0.79 inch
    - 2.0 percent of TE readings 0.79-0.98 inch
    - 0.8 percent of TE readings greater than 0.98 inch

The relative performance values for Shift and TE have been reported previously and are based on data recorded by CSXT OGD sites only.[1] Figure 1 shows graphical representations of Shift and TE.

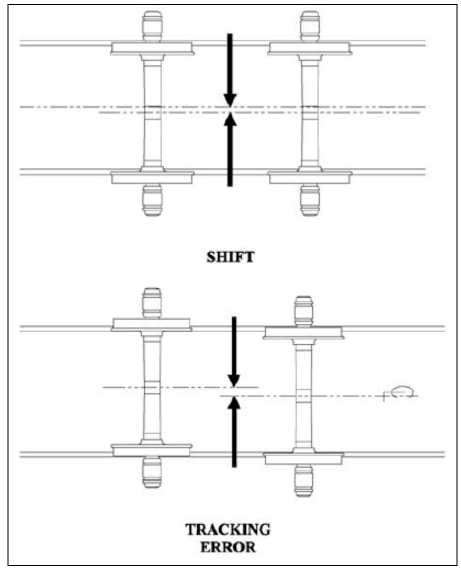

Figure 1. Shift and Tracking Error[1]

The transverse profile of the two wheels of a wheelset can have a large influence over the tracking position of that wheelset. Sometimes one wheel experiences significant wear in the flange and flange root while the mate wheel experiences wear primarily on the tread surface. This condition is called asymmetric wheel wear and can be quantified by comparing flange thickness or wheel tape size between wheels on the same wheelset. Wheelsets with asymmetric wheel wear force themselves into a position with lateral displacement relative to the track centerline in order to produce equivalent rolling radii on each rail of the track. Figure 2 shows an example of wheels with asymmetric wheel wear.

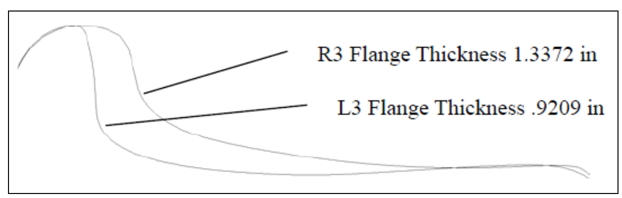

Figure 2. Asymmetric Wheel Wear[1]

PROCEDURE AND RESULTS

Cars that repeatedly showed poor TE and/or Shift readings were routed to shops for inspection and teardown. Both ends of each car were jacked and the trucks were disassembled. Wheel profiles were recorded using a wheel Miniprof™ and the wheel circumference of each wheel was measured using a tape measuring gage.[2] Other measurements included side bearing set up height, center bowl dimensions, wheelbase of side frames, spacing between side frame thrust lugs, and validation of load and control springs. Table 1 lists the results of the teardowns of eight cars, the repairs applied to each car, and the ensuing OGD data in the 14 to 18 months after the repairs.

Table 1: Teardown Results

Car	Year Built	Truck	Detector Identified Problem	Wheel Circumference Mismatch (inches, left wheel minus right wheel)	Wheel Flange Width Mismatch (inches, left wheel minus right wheel)	Other issues	Wheelsets Replaced	Other Components Replaced	Detector Data Results After Teardown and Component Replacement
1	1989	A	Shift	Axle 3=-4/8 Axle 4=-6/8	Axle 3=-0.14 Axle 4=-0.14	• Broken springs • Damaged bolster slopes • Worn side frame ceilings • Cracked center bowl liner	Axle 3 Axle 4	• Bolster • Side frames • Springs • SF ceiling liners	Improved performance
2	1989	A	TE, Shift	Axle 3=-3/8 Axle 4=-6/8	Axle 3=-0.06 Axle 4=-0.27	• Axle 3, friction shoes, springs, and snubbers replaced 4 months before inspection • Ceiling wear on side frames	Axle 4	• Side frames • SF ceiling liners	Some improvement, but: • 8 data pts TE > 0.59 inch • 1 data pt TE > 0.79 inch • 3 data pts shift > 0.39 inch
3	1989	B	TE	Axle 1=1/8 Axle 2=-3/8	Axle 1=0.09 Axle 2=-0.18	• Broken and missing springs • Missing friction snubber • Wrong control springs • Ceiling wear on side frames	Axle 1 Axle 2	• Side frames • Springs • SF ceiling liners	Generally okay, but: • 1 data pt TE > 0.59 inch
4	1982	B	Shift	Axle 1=-6/8 Axle 2=0/8	Axle 1=-0.23 Axle 2=-0.09	• 1 broken load spring • 3/16" difference in measured axle spacing between left and right side frames	Axle 1	• Side frames • Springs • Friction shoes • Bearing adapters • SF ceiling liners	Improved performance, but a small quantity of data
5	1979	B	TE	Axle 1=-4/8 Axle 2=4/8	No readings	• Broken springs • Ceiling wear on side frames	None	• Bolster • Side frames • Springs • Snubbers • Friction wedges • SF ceiling liners	No improvement
6	1979	A	TE	Axle 3=-7/8 Axle 4=8/8	Axle 3=-0.36 Axle 4=0.29	• Side frames wearing on bolster near gibs	Axle 3 Axle 4	• Side bearing blocks	Some improvement, but: • 7 data pts TE > 0.59 inch • 2 data pts TE > 0.79 inch
7	1977	A, B	No data	Axle 1=4/8 Axle 2=1/8 Axle 3=0/8 Axle 4=0/8	Axle 1=-0.03 Axle 2=0.06 Axle 3=0.05 Axle 4=0.10	• 1 broken control spring in A truck • Side frame thrust lug spacing condemnable at all locations • Both bolsters broken	None	• Side frames • Bolsters	B truck: • 2 data pts TE > 0.59 inch • 2 data pts shift > 0.39 inch A truck okay
8	1968	B	No alarms	Axle 1=5/8 Axle 2=6/8	Axle 1=0.02 Axle 2= 0.03	• Worn side frames • Worn bearing adapters • Ceiling wear on side frames	None	• Side frames • Bearing adapters • SF ceiling liners	Generally okay, but: • 1 data pt TE > 0.59 inch

DISCUSSION

When heavy truck wear and asymmetrically worn wheelsets are found together in a truck, both the truck wear and the wheel wear should be addressed. In some cases, the truck has worn into a geometry that is likely to continue producing asymmetric wheel wear at an accelerated rate. It has been pointed out in the past that replacing only the wheelsets in this situation is a temporary fix.[3] For example, although truck wear issues were noted on Car 6, Truck A, none of the truck components was condemnable, and thus only the wheelsets were replaced. This truck exhibited relatively high TE levels following the replacement of both wheelsets.

Car 2, Truck A is another excellent example of the problem with replacing individual components in a complex system. Four months before the inspection, the friction wedges, springs, hydraulic dampers, and Axle 3 were replaced. TE performance improved, but Shift performance immediately became a problem. Four months after the installation of Axle 3, inspectors found a 3/8-inch tape size mismatch between wheels. Following the inspection, Axle 4 was replaced along with the side frames and side frame ceiling liners. This improved the Shift performance, but the TE performance began to degrade, likely because of the tape size mismatch on the 4-month-old Axle 3.

The cars selected for inspection and teardown were all at least 20 years old. Broken springs were common, not only in the truck that caused the performance alarm, but in the mate truck also. Nearly every car inspected required new side frames due to wear issues. Cars 7 and 8 were selected as a way of comparing the condition of the alarmed cars to cars that had not generated alarms. Although the wheelsets were not replaced following the inspections of these cars, the wheel circumference tape size mismatch was similar to the cars that generated alarms. Also, the trucks of cars 7 and 8 exhibited similar wear levels compared to the other cars in the study. Car 7 exceeded some TE and shift criteria following the inspection, most likely due to the presence of wheels with asymmetric wear and despite the replacement of side frames and bolsters. Car 8 also exceeded a TE criterion once following the inspection after having side frames replaced.

The inspection results showed that the OGD is effective at identifying asymmetrically worn wheelsets. However, contributing factors to wheel wear such as truck wear, truck rotational restraint, and brake issues make for a difficult balance between the desire to maximize the life of each component in the car and the desire to minimize the total car maintenance cost over the long term. The owner of a car with poor OGD performance but well maintained trucks may find it beneficial to replace asymmetrically worn wheelsets prior to condemning limits in order to limit the truck wear. Conversely, the owner of a car with poor OGD performance and significant truck wear may find more overall benefit in rebuilding the truck while replacing the wheelsets.

These issues signal an industry need for additional research relating car condition to OGD value. The cause and effect of asymmetric wheel wear patterns is currently under study by the AAR. CSXT, TTX, and the AAR Strategic Research Initiatives Program are jointly funding a test site consisting of an OGD located on tangent track and a nearby OGD located in a 5-degree curve. Strain gages applied to the rails at these sites will be used to relate wheel/rail forces to OGD data. Poorly performing cars will be pulled past the site numerous times, inspected, torn down, repaired, and retested to determine the effects of component repairs. Data from this test site should become available this year. Such additional information could be useful in determining optimal maintenance without a detailed and time consuming truck teardown inspection.

CONCLUSIONS

- OGDs are effective at identifying asymmetrically worn wheelsets based on their tracking position.
- Asymmetrically worn wheels will exhibit non-ideal tracking regardless of the condition of the truck.
- Heavily worn trucks can lead to accelerated asymmetric wheel wear.
- Additional research relating the cause and effect relationships of cars identified by OGDs is planned this year.

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