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TESTS TO CREATE TREAD BUILDUP ON RAILROAD WHEELS

SUMMARY

Tread buildup (TBU) is the formation of metallic material on the tread surface of a railroad wheel. In extreme cases (Figure 1), the resulting impact loads and reduction in relative flange height can result in train accidents.

Figure 1. Wheel with TBU Extending 1 inch Radially from the Tread Surface as a Result of a Wheel Slide Test

The Federal Railroad Administration (FRA) Office of Research, Development, and Technology and the Association of American Railroads (AAR) support research conducted by Transportation Technology Center, Inc. (TTCI) on the root cause of wheel-related accidents. The purpose of this project was to improve wheel performance by gaining a solid understanding of the root causes of TBU.

By inspecting wheels with TBU and the results of wheel slide tests, TTCI researchers determined the root cause of TBU of significant height to be wheel slide caused by excessive brake force.

TTCI conducted wheel slide tests, including variations of railcar speed, slide distance, gross rail load, and moisture at the wheel/rail interface (WRI) to better understanding the conditions necessary to create TBU. TTCI's 90 wheel slide tests created TBU up to 1 radial inch in height from the wheel tread surface. Highest TBU accumulations occurred under dry conditions, longer slide distances, and heavier axle loads. Train speeds between 20–30 mph appeared to optimize TBU height. Although researchers could not provide evidence of the transfer of metallic material from brake shoes to wheels, it cannot be ruled out as a source for some minor cases of TBU, as indicated in some literature references.

Chemical analysis of TBU samples indicated that the source of the material was likely a combination of wheel and rail steel. This finding reinforced the conclusion that wheel slides cause TBU. A microstructural evaluation of several TBU samples found no martensite, a microstructure that results when hot steel is rapidly cooled. A relatively slow conductive heat transfer rate from the irregular contact between the hot TBU and the cooler wheel likely does not provide sufficient rapid cooling for martensite formation.

BACKGROUND

FRA and AAR both have rules designed to restrict wheels with TBU. A wheel with TBU at a radial height of 1/8 inch or greater is condemnable under AAR rules. Although TBU wheel removals are steadily decreasing, accidents attributed to TBU remain the second-leading cause of wheel-related accidents.

An inspection of 21 wheelsets that developed TBU while in service showed indications of wheel sliding on all but one wheelset. The presence of a large flat spot adjacent to the TBU – and heat discoloration concentrated near the flat spot and the TBU – indicated the root cause of the TBU on these wheels was a wheel slide event.

OBJECTIVE AND METHODS

Chemical and microstructural analyses of TBU material provided insight into the source of the material and the TBU formation mechanism. Parametric wheel slide tests were conducted to explore the effects of axle load, moisture at the WRI, speed, and slide distance on the formation of TBU. Most tests were conducted with the brakes completely locked, allowing no wheel rotation. Additional tests were conducted to generate TBU with wheels that were alternately sliding and rolling and with rolling wheels exposed to brake shoes containing metal pickup.

Each wheel slide test began by applying the brakes to a stationary car, accelerating to the test speed, maintaining the test speed, and decelerating to a stop. An aluminum gondola car equipped with truck-mounted brakes was used for the test. The handbrake and airbrake were applied to the B-end truck only, and the wheelsets in this truck were slid the entire test distance. All test wheelsets had significant accumulated mileage prior to the wheel slide testing, and therefore had work-hardened tread surfaces.

FINDINGS

A chemical analysis of TBU samples indicated the source of the material was likely a combination of wheel and rail steel. The TBU material from two wheels removed from revenue service and eight wheels that were dragged on the tracks by TTCI were evaluated for chemical content. The carbon percentage in the TBU material was within the range defined by Class C wheel steel and rail steel (0.67 to 1.0 percent). The percentages of other elements in the TBU samples were generally within the specified limits for wheel steel.

Evaluation of the microstructure of several TBU samples showed a pearlitic microstructure with a notable absence of any martensite, indicating that any heating of the steel from sliding either did not reach the austenitic transformation temperature (approximately 727 °C) or more likely did not cool at a sufficient rate to form martensite.

Three wheel/rail friction conditions and three car weights were tested during the 54 short-distance (4,000 feet) wheel slide tests at speeds ranging from 5 to 30 mph. Dry, wet, and lubricated were the three friction conditions. A water-spray system was used to continually cover the rails with either water or a mixture of water and soap. The average TBU was highest when the rail was dry and the car loaded to its heaviest test condition (72,200 lbs gross rail load). Figure 2 shows the average TBU height from the short wheel slide tests.

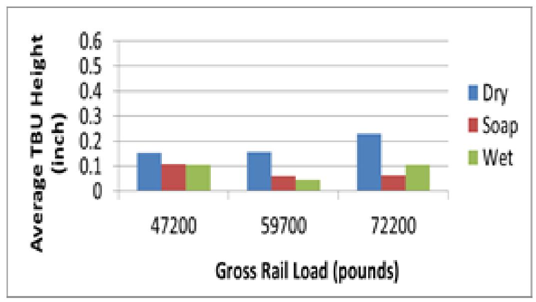

Figure 2. TBU Height as a Function of Gross Rail Load

TTCI conducted 36 wheel slide tests with an empty car (47,200 lbs gross rail load) over longer distances to investigate the effect of increased slide distance. Between one and three laps were completed on a track loop approximately 9 miles long. The laps were made at four speeds: 10, 20, 30, and 40 mph. Figure 3 shows the average TBU separated by speed and wheel/rail friction condition.

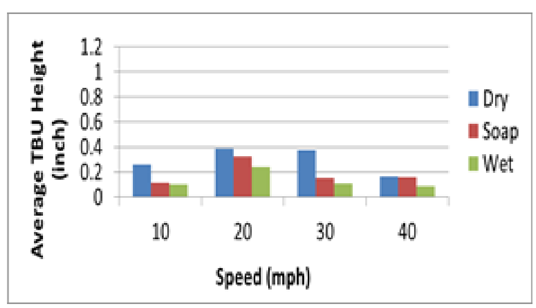

Figure 3. TBU Height as a Function of Speed

The highest average values of TBU height occurred during the 20 and 30 mph runs. Figure 4 shows the average TBU heights recorded at each wheel slide distance. In general, the TBU heights were greatest when the rail was dry and after the longest wheel slide distance (27 miles).

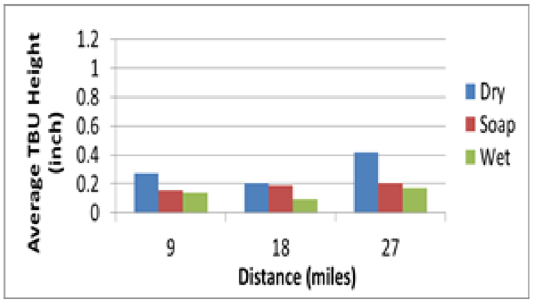

Figure 4. TBU Height as a Function of Slide Distance

TTCI attempted to create TBU around the circumference of the wheel by applying the handbrake tightly and releasing the airbrakes. During this testing, the wheels were sliding on the rails at intermittent times as desired; the test crew could see TBU on the wheel from their vantage point. However, after a significant ratcheting, the wheels ceased sliding and began to roll. After this rolling began, any evidence of TBU began to disappear. All TBU was gone by the end of the test.

Some researchers theorize that brake shoes with metal pickup are a possible source of TBU. TTCI ran three tests with brake shoes containing metal pickup. A light handbrake application was used to keep the brake shoes in contact with the wheels as they rotated. Test speeds were 20–40 mph, and the test distance was 9 miles. Test results showed no measurable signs of TBU, and, in most cases, the pickup metal in the shoe had decreased in size.

CONCLUSIONS

The root cause of significant TBU was determined to be wheel slide caused by excessive brake force. During wheel slide tests, TBU accumulated to its greatest heights under dry conditions, longer slide distances, and heavier axle loads. Train speeds between 20–30 mph appeared to optimize TBU height. Chemical analysis of TBU samples indicated that the source of the material was likely a combination of wheel and rail steel. A microstructural evaluation of several TBU samples found no martensite. A relatively slow conductive heat transfer rate from the irregular contact between the hot TBU and the cooler wheel likely did not provide enough rapid cooling for martensite formation.

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