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Radio Frequency Identification to Track Freight Car Truck Components at the Facility for Accelerated Service Testing

SUMMARY

Transportation Technology Center, Inc. (TTCI), a wholly owned subsidiary of the Association of American Railroads (AAR), conducted a radio frequency identification demonstration (RFID) test at the Facility for Accelerated Service Testing (FAST) on the High Tonnage Loop (HTL) located at the Transportation Technology Center in Pueblo, Colorado. This 10-week test showed that RFID technology, which has traditionally been used to track packages and boxes, can be used to track railroad freight-car truck components at speeds of 10 to 40 miles per hour (mph).

Twenty-six passive RFID tags were bonded to the wheels, axles, side frames, and bolsters on the trucks of three cars of the FAST train, for a total of 156 tags. Two of the three test cars had aluminum carbodies; the third had steel.

This test evaluated two RFID scanners with four antennae each and an automatic equipment identification reader. Four RFID scanner antennae were deployed between the rails in different orientations (Figure 1), and two antennae were mounted vertically on either side of the track to evaluate the effect of antenna position on scanning efficiency.

The RFID tags mounted to the wheels, axles, side frames, and bolsters were read each lap for approximately 13,000 miles at FAST. RFID tags mounted to the couplers were read well at low speeds (5 to 10 mph). At 40 mph, many RFID tags were missed due to a narrow window of visibility. Carbody material (aluminum or steel) did not appear to affect how well RFID tags were read. Five wheel-mounted RFID tags fell off, likely due to inadequate degreasing of the area where the epoxy adhesive was applied.

Figure 1. RFID Antennae Mounted between Rails

INTRODUCTION AND BACKGROUND

Radio frequency identification demonstration (RFID) is an automatic method that relies on storing and retrieving data remotely using devices called RFID tags or transponders. An RFID tag can be attached to or incorporated into a product, animal, or person for the purpose of identification using radio waves. RFID tags contain silicon chips and antennae. Figure 2 illustrates a typical RFID tag, not to scale. Passive tags require no internal power source (e.g., no batteries), whereas active tags require a power source (e.g., batteries).

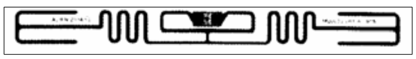

Figure 2. Typical RFID Tag.

RFID tags are widely used to track commodities, equipment, shipments, inventory, animals, and many other items with minimal human intervention. RFID is an automated data collection system that enables businesses to wirelessly capture and move data using radio waves. A typical system consists of RFID tags with an embedded, unique identifier for the product or object being moved. An RFID reader decodes the data on the tag, and a host system or server processes and manages the information gathered.

The Association of American Railroads' (AAR) Coupling Systems & Track Castings Committee (CS&TCC) is responsible for development, implementation, revision, and interpretation of the AAR standards, specifications, and recommended practices governing coupling systems and truck castings for use in North American interchange service.

The CS&TCC is also responsible for design approval of castings and certification of castings foundries. According to the AAR, there are over 1.5 million freight cars in service, which represent approximately 9 million truck bolsters and side frames. There are more than 3 million couplers. Implementation of an RFID system would enable the railroads to identify, find, and remove from service components that have been deemed to be defective.

The CS&TCC and the AAR Strategic Research Initiatives Heavy Axle Load Program sponsored this RFID test at FAST to demonstrate the ability to track these components using passive RFID tags.

One of the challenges of using RFID with freight car bolsters, side frames, and couplers is the large mass (metal) of the castings. The radio waves that RFID tags use tend to bounce off metal. An assembled freight car truck weighs approximately 8,000 pounds (lb) and a freight car's coupler weighs approximately 600lb. Two of the carbodies were aluminum and one was steel. Metal also causes eddy currents in the vicinity of the RFID reader antenna that absorb radio frequency energy, thus reducing the overall effectiveness of the RFID field. These eddy currents also create their own magnetic field that is perpendicular to the metal surface. This perpendicular magnetic field adversely affects the reader field.

Metal can also detune both reader and transponder antenna, causing added parasitic capacitance (energy drain caused by the electromagnetic friction from the metal) and reduced system performance. At some frequencies, the energy reflected by metal creates interference between the tag and reader. RFID systems used in the vicinity of massive metal objects can suffer from reductions in actual read and write data exchange rates.

The railroad industry presents some other unique challenges to the placement of RFID transponders on freight car components. The environment that these components operate in is severe, as they encounter shock, vibration, extreme temperature variations, and inclement weather. The transponder has to be located where it will not be damaged. The car itself presents some challenges for placing the RFID reader. Because railroad freight cars can sit in railroad yards, railroad sidings, and shipping facilities for extended periods of time between uses, only passive RFID transponders can be used.

INSTRUMENTATION

For the RFID test, 26 RFID tags were glued with epoxy adhesive onto the bolsters, side frames, wheels, and axles of three 125-ton capacity gondola cars, as Figures 3 and 4 illustrate. In addition, the couplers of the three cars were also instrumented with RFID tags.

The RFID tags were mounted to the inside and outside plate of the wheels, the inside and outside of the side frames, the center of the axles, and on either side of the bolsters. The couplers were also instrumented with RFID tags.

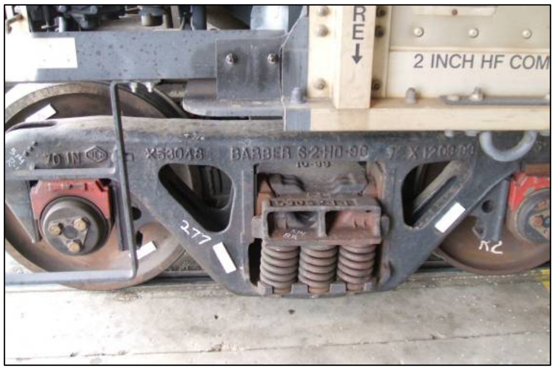

Figure 3. RFID Tags Bonded to the Side Frames.

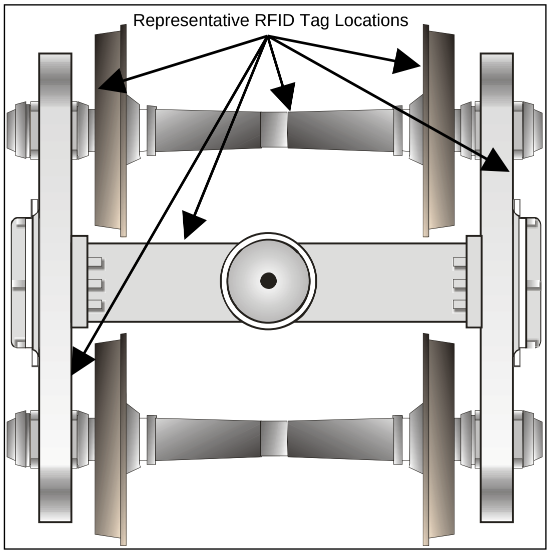

Figure 4. Representative RFID Tag Locations.

The wayside installation is located in a tangent section on the HTL. The location has a bungalow close to the track with two tri-leg towers next to the track. A total of eight antennae are being used in various orientations and configurations to determine which combination is best able to scan the tags mounted on the cars.

Two antennae were mounted vertically on either side of the track. Figure 5 shows one of these antenna. Four antennae were mounted between the rails, as Figure 1 shows. In addition, an automatic equipment identification reader was installed to correlate the car number to the RFID tags on that car.

A web camera with pan/tilt capability is mounted to the top of one of the towers. This allows remote monitoring of the site while testing is in progress. Alien Technologies supplied the tags, antennae, and camera. The three scanners and a web camera are accessible by using the TTCI wireless local area network.

Figure 5. Tower Mounted Antennae.

RESULTS

The most challenging RFID tags to read were the tags mounted to the wheels and axles due to the rotational speed of the wheels and axles and forward train velocity (40 mph).

Every RFID tag mounted to the wheels and axles were read on each lap at FAST. The tags mounted to the inside of the wheel plate were read by the outside mounted RFID antennae. It is believed that this is due to reflection of the signal off of the bolster or opposite side frame or wheel.

The tags mounted to the side frames and bolsters were read each lap. The tags mounted to the couplers were read easier at low speeds; however, at 40 mph, many RFID tags on the coupler were missed. This appears to be due to the small line of sight that the scanners have between cars to read the tags. Carbody material (aluminum or steel) did not appear to affect how well RFID tags were read.

More study is needed to determine the long-term durability of RFID tags used in the railroad freight car environment.

During 10 weeks of train operations (approximately 13,000 miles), five wheel mounted RFID tags fell off. It is likely that this was due to inadequate degreasing of the area where the adhesive was applied. Also, the load environment on the wheels was more severe than at the other locations. There were no suspension components between the wheel-mounted tags and the rails; however, there are suspension components between tags on the other car components. Improved cleaning and (if necessary) better epoxy should result in a more durable bond.

CONCLUSIONS

The RFID demonstration test at FAST showed that RFID tags can be attached to railroad freight car casting components and can be used to identify casting components. This technology will give the railroads a low-cost method to track these components and remove potentially defective components and components exhibiting performance issues from service.

The FAST Program will begin to use RFID tags to track major car components. This will facilitate monitoring of how many miles each of these components will accumulate over a period of time and how much maintenance will be needed.

FUTURE

The RFID track-side equipment used for this demonstration will remain in place to be used as a continuing test bed for the advancement of RFID technology for the railroad industry. New types of RFID systems will be tested at FAST; for example, a new tag that is about half the size of the tags originally placed on the test cars for this RFID test.

ACKNOWLEDGMENTS

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