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RESEARCH RESULTS

FRA OFFICE OF RESEARCH, DEVELOPMENT & TECHNOLOGY

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Investigation of Radiography Technology for Bolster and Side Frame Inspections

SUMMARY

Information about inhomogeneous areas in castings before they leave the manufacturer could provide useful information for manufacturers and customers. Some of this information could be used to estimate the life of the component. The Federal Railroad Administration (FRA) tasked Transportation Technology Center, Inc. (TTCI) to investigate radiography as an inspection tool on castings.

Radiography can be used to examine cast components without altering any portion of the casting. The digital radiography used in this test was relatively quick compared to other nondestructive testing (NDT) methods. Radiography also identified defects that would not have been detected without cutting into the casting and found defects that may be difficult to identify with ultrasonic transducers.

For the bolster sections examined in this test, radiography was easy to set up and provided clear images (Figure 1 and Figure 2).

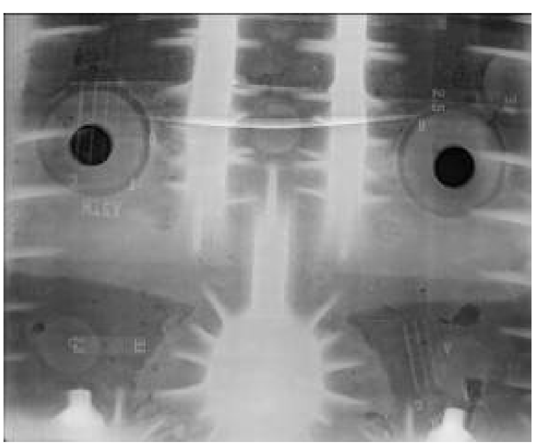

Figure 1: Radiograph of a Bolster with Defects

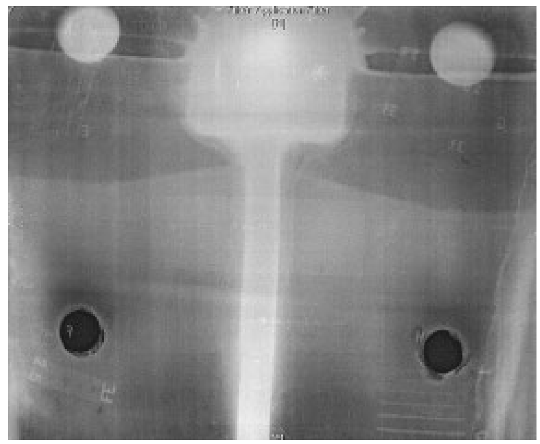

Figure 2: Radiograph of a Bolster with Minimal Defects

However, problems were encountered when examining the pedestal jaw of the side frames. The geometry between the diagonal tension member and the spring seat made it difficult to get the imaging plate near the area of interest.

Using radiography, defects, including hot tears, shrinkage, porosity, and voids, were identified in several bolsters.

BACKGROUND

The Association of American Railroads' (AAR) Coupling System and Truck Castings Committee and TTCI are examining modifications to improve the performance and reduce the occurrence of brittle failures of cast components for the rail industry. FRA has collaborated with these groups to study possible solutions. TTCI is investigating the use of NDT inspection methods to improve the quality of castings and the ease of implementing them.

OBJECTIVES

This project focused on improving the chemistry, casting quality, and life of grade B+ castings according to AAR's *Manual of Standards and Recommended Practices,* Specification M-201 (1). Radiography technology was used to examine the quality of castings, particularly the critical areas of bolsters and side frames cast with grade B+ material.

METHODS

Researchers tested seven bolsters and five side frames with radiography. Each component was new from the foundry and had not been put into service.

General Electric was hired to provide and operate a CRx Flex scanner, which included the computer, software, and imaging plates. Technicians from Intermountain Testing provided the iridium 192 source and ensured radiography safety precautions.

Figure 3 shows two locations, A and B, on the bolsters designated for radiography and one location, C, on the side frames. For the remainder of this report, the labels in Figure 3 will be used to describe the location of the radiographs. These locations were chosen based on previous analysis.

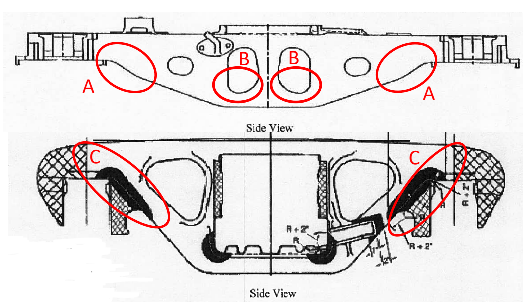

Figure 3: Bolster and Side Frame Radiography Locations

Radiography at Location B was conducted using a single-wall exposure and single-wall view. Location A used a double-wall exposure and double-wall view. Location C used a double-wall exposure and a single-wall view. The exposure time for Location A was approximately 21 minutes. Locations B and C were exposed for considerably less time – under 5 minutes.

RESULTS

Defects, including hot tears, shrinkage, voids, and porosity, were found in castings during this study.

A hot tear can be caused by thermal effects, casting restraints, material composition, and by two physical factors in the partially solidified zone: tensile loading and insufficient liquid feeding (2). If the hot tear is oriented in a direction of high stress, the tear could propagate and cause a failure. Small hot tears were found in six of the seven bolsters; Figure 4 shows one such defect.

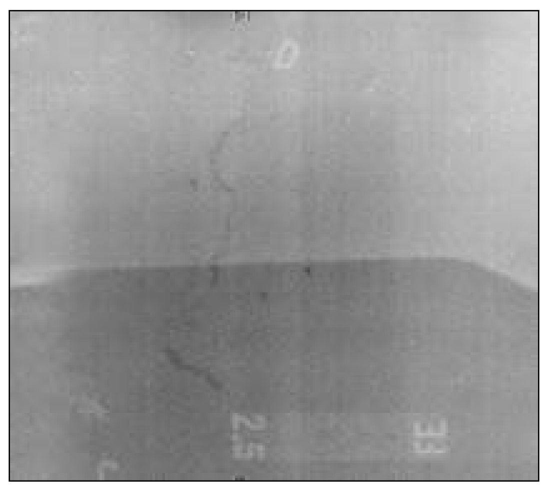

Figure 4: Example of a Hot Tear in Location A of a Bolster

Shrinkage was found in all of the castings examined. Using sample radiographs of cast materials, levels of shrinkage and porosity were assigned to each bolster. Two of the castings had shrinkage levels of 4 and 5 in concentrated areas. For the entire bolster, shrinkage levels of 3 and 4 were assigned. The other five bolsters had lower shrinkage levels. Shrinkage is mainly caused by restriction of feeding in the cast structure assisted by differential cooling in areas of the casting. Shrinkage was found on the both the upper and lower areas of Location A. Figure 5 shows an example of filamentary shrinkage in one of the castings. Figure 6 is an example of shrinkage in the pedestal jaw radius of a side frame.

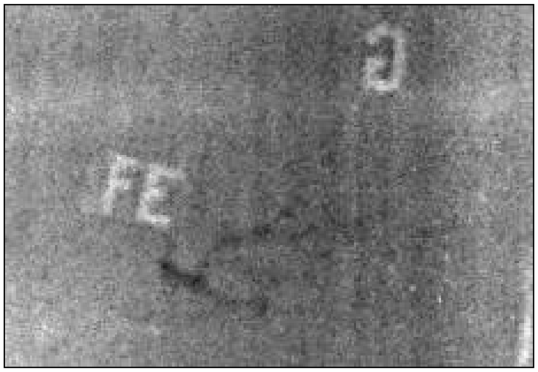

Figure 5: Example of Shrinkage in Location A of a Bolster

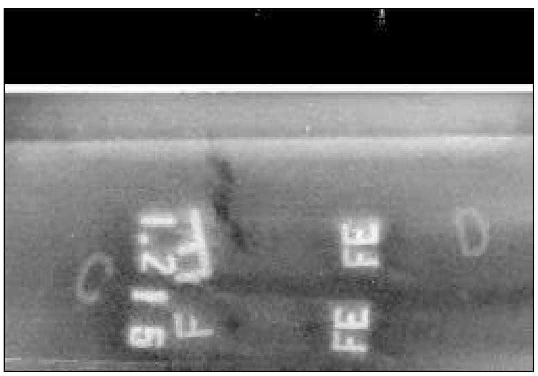

Figure 6: Shrinkage in Location C of a Side Frame

Evidence of porosity and voids were also found in some of the bolsters tested. Voids will occur when the casting feeding is inadequate for the local volume. Porosity is usually caused by gas that has been trapped in the casting. Gas can be trapped because the risers are too small for the it to escape – or the sand in the mold is too fine or wet. Figure 7 shows both voids and porosity in a bolster. Porosity levels were assigned to each bolster. The same two bolsters with high levels of shrinkage also had level 4 porosity.

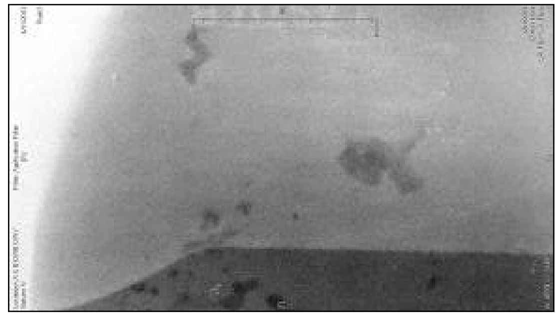

Figure 7: Example Porosity and Voids in Location A of a Bolster

CONCLUSIONS

The use of radiography in this test showed a capacity to locate defects in large castings. Unlike ultrasonic inspections, radiography does not require a special surface finish. Also, even for thicker wall sections and double-wall exposures, the time required to acquire a clear image of a critical area can be less than 25 minutes.

For the bolster sections examined in this test, radiography was easy to set up and it provided clear images. However, problems were encountered when examining the pedestal jaw of the side frames. The geometry of Location B made it difficult to get the imaging plate near the area of interest. To receive the accurate size and depth of defects in those areas, special imaging plates may be required. The use of digital film was very convenient because of its quick development and reusability. However, many in the radiography industry maintain that traditional film should be used if the main goal is to find cracks.

FUTURE ACTION

Radiography has the potential to be more widely used in manufacturing and repair shops to verify the quality of castings.

REFERENCES

1. Association of American Railroads. (2005). *Manual of Standards and Recommended Practices*. Section S, Casting Details Specification M-201. Washington, DC.

2. C. Monroe and C. Beckermann. (2005). Development of a hot tear indicator for steel castings. Iowa City, IA: University of Iowa.

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TTCI conducted this research; Devin Sammon and Dan Carter were the principal investigators.

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KEYWORDS

Radiography, grade B+, nondestructive testing, NDT, casting defects