M. E. Williams and Associates, Inc.
"Excellence in Metallurgical Engineering"

12825 385th Avenue
Waseca, MN 56093

Case Study: Very High Cycle Fatigue

By

Merlin E. Williams, P.E.

Subject

Examination of a Coupler Pin that failed to determine cause of failure and to identify type of material that it was fabricated from. The pin was examined by visual examination, hardness testing, and metallographic examination. This was a custom coupler pin. The manufacturer, material, and heat treatment were unknown, and the client needed to produce a replacement that would have an equal or better service life.

Visual Examination

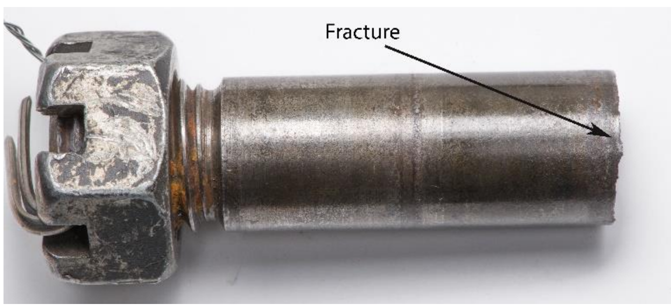

Figure 1 – Broken Coupler Pin

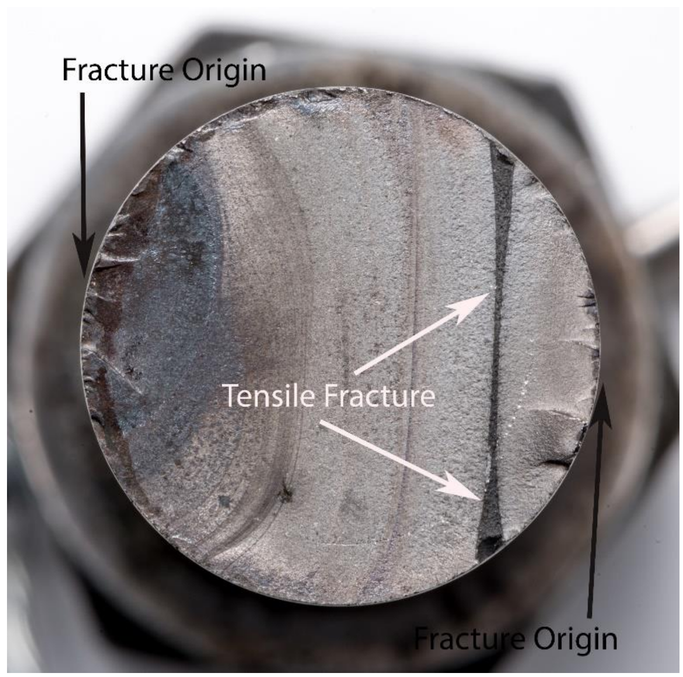

Figure 2 – Coupler Pin Fracture Surface

Close examination of Figure 1 showed that the surface of the pin had very fine pits.

Figure 2 shows the fracture surface of the coupler pin. The pin clearly failed by very high cycle fatigue. The fatigue started on both sides of the pin. There was a black band near the right side, as shown in the photo. The band was 0.56 inches long, the width varying from 0.010 inches to 0.030 inches, and there was an area of about 0.011 square inches. The material in the black band appeared to have failed by tensile fracture, and may have been the final failure of the coupler pin.

Hardness Testing

The hardness testing was done according to ASTM E385, using a Vickers indenter and a 500 gram load. The results of the testing are given in the table that follows.

Hardness Test Data for High Roller Coupler Pin (Rockwell C Scale)					
Location	Vickers	STD DEV	MAX VALUE	MIN VALUE	HARDNESS
Core	283.00	10.43	299.00	270.00	27.42 HRC

The hardness of the pin was 27.4 on the Rockwell C Scale, indicating that the tensile strength of the steel used for the pin was about 120,000 psi. This means that if the black band area in Figure 3 was the last area to break, the load on the pin was about 1300 pounds at the time of failure.

Metallographic Examination

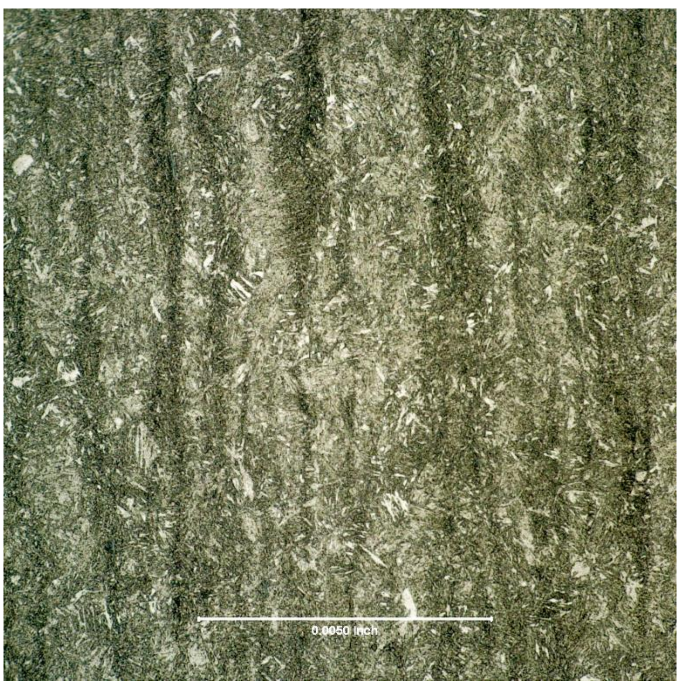

Figure 3 – 400X Microstructure of Coupler Pin

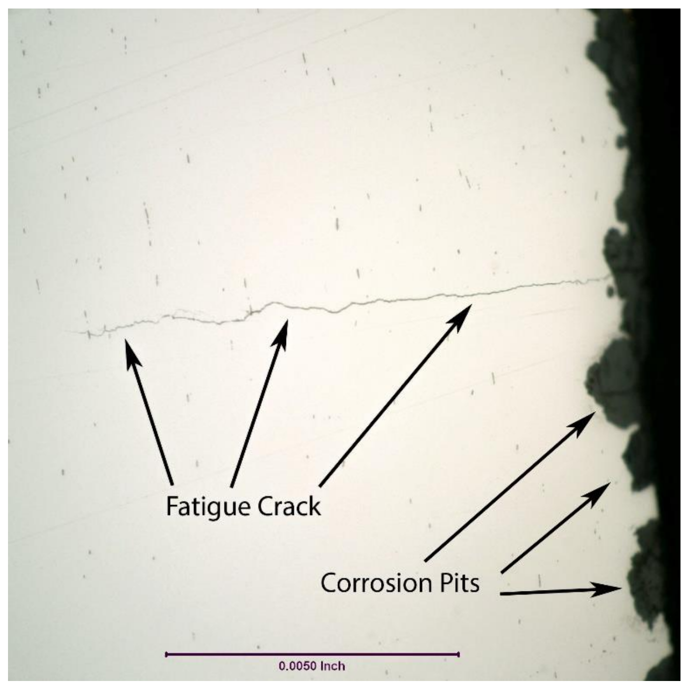

Figure 4 – 400X Internal Fatigue Crack

Figure 3 shows the microstructure of the Coupler Pin, which is tempered martensite. The microstructure and hardness of 27.4 Rockwell C scale indicates that the steel used for the coupler was probably mill heat treated 8620.

Figure 4 shows one of several internal fatigue cracks found in the metallographic cross section. All the fatigue cracks appeared to originate in the corrosion pits on the outside diameter of the Coupler Pin.

Conclusions

1. The Coupler Pin failed by very high cycle fatigue, with the fatigue cracks initiating in corrosion pits on the pin’s surface.

2. The Coupler Pin was fabricated from mill heat treated 8620 steel.

3. The pin that failed had exceeded its useful life.

Recommendation

Fabricate replacement pin from mill heat treated 8620, 4140, or 4340 steel. Note that mill heat treated 4340 will have better fatigue life than the other two steels.