

# NATIONAL TRANSPORTATION SAFETY BOARD

Office of Research and Engineering  
Materials Laboratory Division  
Washington, D.C. 20594



June 16, 2020

## MATERIALS LABORATORY FACTUAL REPORT

Report No. 20-013

### A. ACCIDENT INFORMATION

Place : Fredericksburg, Texas  
Date : January 17, 2019  
Vehicle : Beech A36, N2021T  
NTSB No. : CEN19LA055  
Investigator : Craig Hatch, AS-CEN

### B. COMPONENTS EXAMINED

Camshaft and crankshaft with attached counterweights and number 6 connecting rod.

### C. DETAILS OF THE EXAMINATION

An overall view of the submitted camshaft and crankshaft are shown in figure 1. The crankshaft was fractured at the forward fillet area of the number 6 connecting rod journal, and the number 6 connecting rod assembly and counterweights remained attached to the fractured crankshaft. The camshaft was fractured between the lobes for actuating the number 6 cylinder valves. The accident engine was a Lycoming TIO-540-J2BD engine, and the components had been exposed to a post-crash fire.

According to the engine maintenance log for the accident engine, the engine had been overhauled in December 2010 and had approximately 440 hours time in service since overhaul (TSOH) at the time of the last maintenance action (oil change and engine baffle replacement) on December 21, 2018. The last recorded oil filter check occurred at 410.9 hours TSOH during the last 100-hour inspection on October 1, 2018, and no metal was found. The last 100-hour inspection entry also noted the external magneto timing was reset to 20 degrees.

The fracture in the camshaft was oriented in the transverse plane. The area adjacent to the fracture showed deformation and impact marks consistent with overstress fracture due to impact from an adjacent engine component.

The crankshaft was part number LW 10346 with serial number 92762. According to a representative from Lycoming Engines, the crankshaft was manufactured in the 1970's and was not within the range of serial numbers affected by a service bulletin.

After an initial visual examination, the number 6 connecting rod was disassembled from the aft crankshaft piece, and the disassembled connecting rod is shown in figure 2. The connecting rod had a uniform darkened appearance with coked oil on the surface consistent with exposure to heat from the post-crash fire. The connecting rod bearing halves showed heat tinting, and Babbitt material was missing from more than half of the interior surface. The underlying copper layer showed limited scoring (the connecting rod was found free to rotate on the crankshaft as-received). The forward and aft faces of the connecting rod showed rub damage consistent with sliding contact with the crankshaft fillet radius and cheeks at the forward and aft end of the number 6 journal. Corresponding rub contact damage was observed on the crankshaft fillets and cheeks for the number 6 journal as noted in figure 3.

The diameter of the number 6 connecting rod journal was measured using a micrometer, and the diameter was 2.249 inches, consistent with the design minimum value for the crankshaft as shown on the crankshaft engineering drawing provided by a Lycoming Engines representative. The distance between the cheeks at the forward and aft sides of the crankshaft journal was 1.340 inches, which was within the design value range specified on the engineering drawing. The width of the number 6 connecting rod was also measured at the bearing end. The rub damage was greatest near the bearing split line, so the width was measured in an area that appeared least damaged by contact with the crankshaft cheeks near the connecting rod centerline. The measured width was 1.328 inches, which was 0.003 inch less than the minimum value for width at that location as specified on the connecting rod engineering drawing.

The fracture in the crankshaft as shown in figure 3 had curving crack arrest marks consistent with fatigue. The fatigue region extended across most of the thickness of the cheek and into the counterweight attachment flange. However, the total extent of the fatigue region could not be absolutely determined due to post-fracture damage. The fatigue features emanated from an origin area at the surface of the cheek at the forward end of the number 6 connecting rod journal. Origin areas on both the forward and aft sides of the fracture were damaged by post-fracture contact, but the fracture surface on the forward side of the fracture had relatively less damage. Therefore, the images used in this report focus on the forward fracture face.

To facilitate further examination of the forward fracture face, a water-cooled abrasive saw was used to make a transverse cut through the number 3 main bearing. The photograph shown in figure 3 was taken after this cut had been made. Next, the counterweights were disassembled from the piece, and a cut was made through the cheek between the fracture surface and the number 5 connecting rod journal using another water-cooled abrasive saw. After the cuts were complete, the piece with the fracture surface was cleaned in an ultrasonic cleaner using a solution of Alconox detergent and water followed by soaking in Evapo-Rust<sup>1</sup> deoxidizer with subsequent gentle brushing.

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<sup>1</sup> Evapo-Rust is manufactured by Harris International Laboratories, Springdale, Arkansas.

A view of the crankshaft fracture surface after disassembly, sectioning, cleaning, and deoxidizing is shown in figure 4. The fatigue features emanated from a primary origin as indicated in figure 4 and shown at higher magnification in figure 5. Secondary origins were located adjacent to the primary origin, as indicated with unlabeled arrows in figure 4. Ratchet marks<sup>2</sup> were observed radiating from the origin area, consistent with multiple origins. More crack arrest lines were observed emanating from the primary origin relative to the secondary origins, indicating that the secondary origins developed later as the crack progressed from the primary origin. Unlabeled arrows in figure 5 indicate crack arrest lines that were associated only with the primary origin.

Relatively prominent crack arrest lines were observed close to the origin as shown in figure 5 and across much of the fracture as shown in figure 6. Crack growth appeared to progress in a wavy pattern, which were highlighted by side-lighting to show an alternating light and dark pattern when viewed optically as shown in figure 6. The fracture surface was further examined using a scanning electron microscope (SEM). An SEM image of the primary origin area is shown in figure 7, and an image of crack arrest lines near the middle of the fatigue region is shown in figure 8. The images shown in figure 7 and 8 are at relatively low magnification. The fracture surface was examined at higher magnification, but fine fracture features had been mostly obliterated by post-fracture rubbing damage and oxidation.

Using both optical and SEM images of the fracture surface, the number of crack arrest lines was counted from the primary origin to a rubbed area at the forward end of the fracture surface (see figure 4). In most cases, a light and dark portion of the wavy pattern was observed between each crack arrest line, particularly near the middle portion of the fracture, consistent with a change in reflected light (optical images) or reflected secondary electrons (SEM images) due to the change in slope associated with each wave-like feature. The total number of observed crack arrest lines was 46.

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Senior Materials Engineer

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<sup>2</sup> A ratchet mark is a small step in the fracture surface formed when two adjacent fatigue cracks originate on slightly offset planes.



Figure 1. Overall view of the submitted camshaft and crankshaft pieces with attached connecting rod and counterweights.



Figure 2. Number 6 connecting rod assembly after disassembly from the crankshaft.



Figure 3. Overall view of the forward side of the fracture after the crankshaft was cut through the number 3 main journal and before the fracture surface was cleaned.

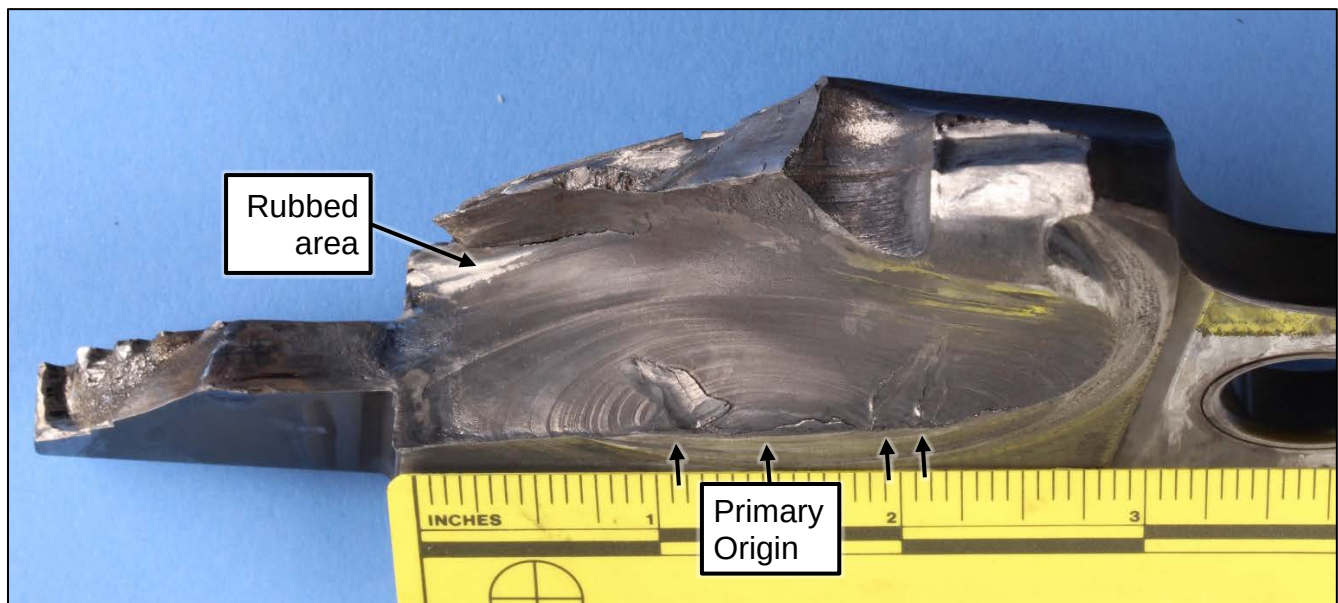


Figure 4. Overall view of the forward side of the fracture after the counterweights were disassembled and the crankshaft cheek was cut to facilitate further examination of the fracture features. The fracture surface is shown after cleaning and deoxidation.

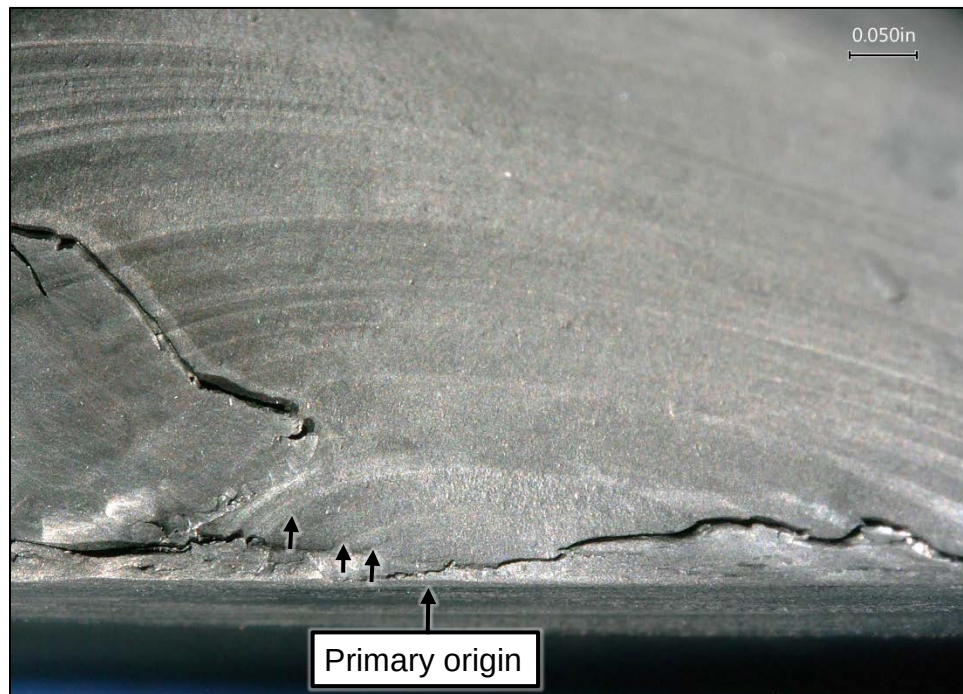


Figure 5. Optical image of the primary origin after cleaning and deoxidation. Unlabeled arrows indicate several crack arrest lines near the origin.

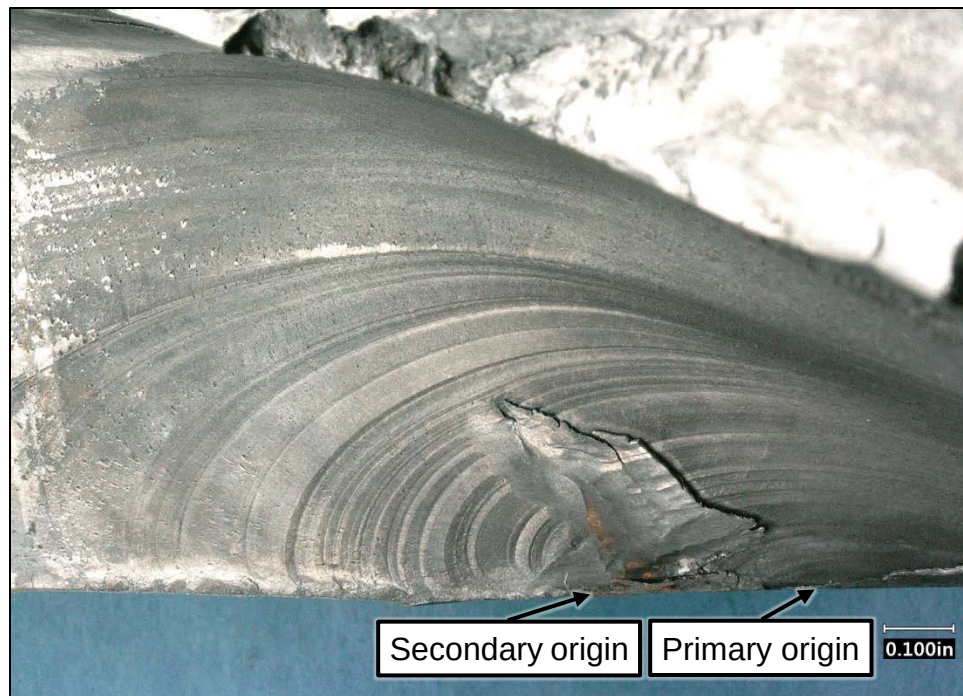


Figure 6. Optical image of the cleaned and deoxidized fracture surface showing crack arrest lines emanating from the primary and secondary origins.

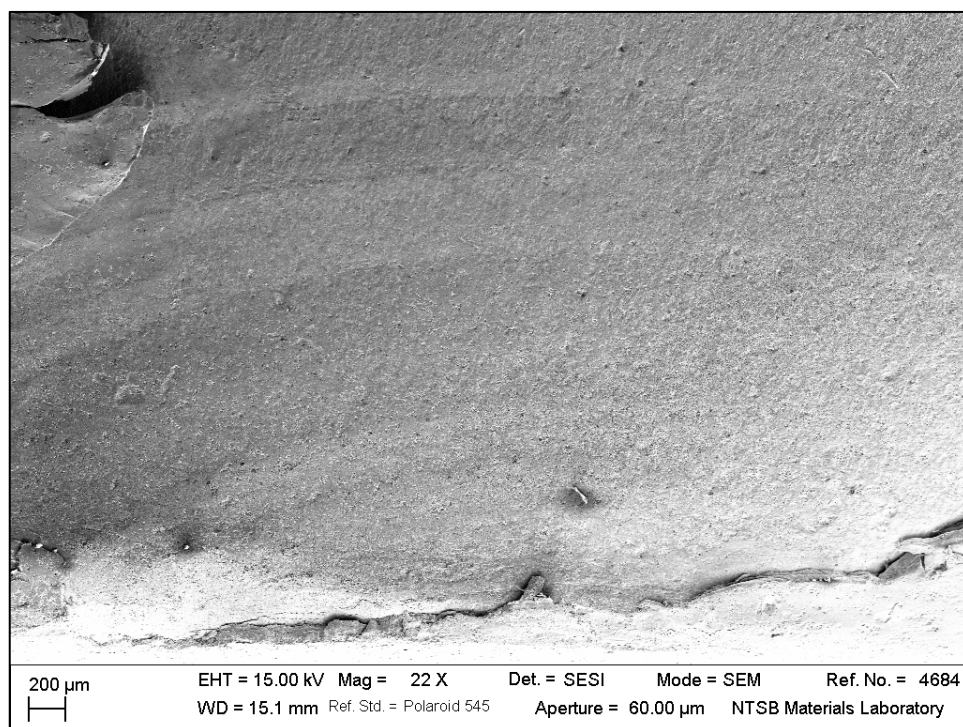


Figure 7. SEM image of the primary origin area.

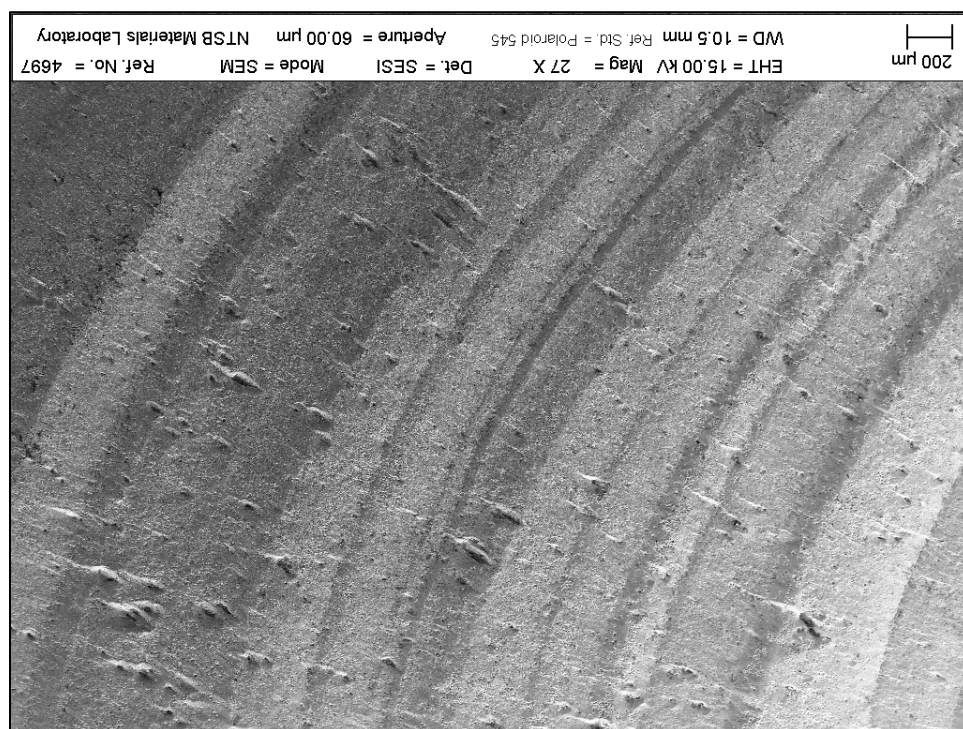


Figure 8. SEM image of crack arrest lines in the middle portion of the fatigue region.