NATIONAL TRANSPORTATION SAFETY BOARD

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

April 21, 2014

MATERIALS LABORATORY FACTUAL REPORT Report No. 14-008

A. ACCIDENT

Place	: Fallon, Nevada
Date	: July 10, 2012
Vehicle	: Raytheon A36, N517DJ
NTSB No.	: WPR13LA321
Investigator	: Patrick Jones, AS-WPR

B. COMPONENTS EXAMINED

#5 and # 6 connecting rod cap, engine rod bolts, attachment nuts

C. DETAILS OF THE EXAMINATION

On July 10, 2013, about 0445 Pacific daylight time (PDT), a Raytheon A36 operated by Silver Sage Aviation, experienced catastrophic engine failure during initial climb out, resulting in an off airport landing near Fallon Municipal Airport (FLX), Fallon, Nevada. The airplane sustained "substantial damage," but the commercial pilot and three passengers sustained minor injuries. The aircraft engine was a Continental IO-550-B.

The connecting rod cap, engine rod bolts, and attachment nuts from the #5 and #6 positions were submitted to the NTSB Materials Lab for examination, along with fragments of a bolt from the #5 connecting rod assembly[1]. The engine rod bolts and nuts for the #1 through #4 positions were also submitted—these bolts were intact and showed no visually observable damage. The inner contact surface of the #6 connecting rod cap exhibited circumferential wear marks consistent with rotational contact with the adjacent crankshaft journal surface. The cap exhibited damage on the outer surfaces and rod bolts consistent with post-impact forces. The bolts and nuts for the #6 rod cap were intact.

Of particular note was the #5 connecting rod cap assembly, shown in Figure 1. One of the bolts had fractured at midlength, whereas the opposite bolt was intact with the nut still fastened. This intact bolt still held a fragment of the connecting rod yoke against the rod cap. The #5 cap exhibited damage on all surfaces consistent with ground impact.

[1] Continental (TCM) crankshafts journals are numbered from the rear of the engine to the forward. Main and cylinder journals are numbered independently. The connecting rod numbers correspond to the crankshaft journals.

Figure 2 shows the fracture surface of the #5 connecting rod yoke fragment attached to the cap. The fracture features show crack arrest marks and ratchet marks, which are consistent with progressive fatigue cracking. The progressive cracking features were present over approximately 75% of the fracture surface. As shown in Figure 3, the crack propagated inward approximately 45° from the bolt direction, but approximately 90° to the connecting rod yoke fragment direction. The crack initiated on the outer surface adjacent to the nut-facing boss (Figure 4).

The connecting rod fragment fracture surface was inspected using a scanning electron microscope (SEM). As illustrated in Figure 5, the majority of the fracture surface exhibited striations, indicative of fatigue cracking. The crack initiation site is illustrated in Figure 6 and Figure 7. The initiation site shows material smearing over the beginning of the crack. In addition, inspection of the fracture surface using backscattered electron imaging revealed no dissimilar material embedded at the crack initiation site (see Figure 7)[2]. The end of the fracture surface exhibited dimple rupture, consistent with overstress.

The chemical composition of the connecting rod fragment was inspected using energy dispersive X-ray spectroscopy (EDS). The composition was consistent with nominal AISI 4340 and 4337, the prescribed materials for the connecting rod and rod cap. The outer surfaces of the part are to be shot peened[3]. The surface of the nut-facing boss exhibited small pockmarked dimples consistent with a shot-peened surface.

The fracture surface of the broken bolt from the #5 connecting rod assembly is shown in Figure 8. Most of the fracture surface had been obliterated by smearing, consistent with post-impact damage. The portions of the original fracture surface that remained are illustrated in Figure 9. The fracture surface was inspected using a SEM. As shown in Figure 10, the fracture features were consistent with dimple rupture, indicative of overstress. There were no indications of other failure modes. The chemical composition of the connecting bolt was inspected using EDS. The composition was consistent with nominal AISI 4340 and 4337.

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[2] SEM images produced using backscattered electrons have contrast that is associated with atomic weight of the elements in the image. Materials with elements having higher atomic weights appear relatively lighter than others having elements with lower atomic weights.

[3] Shot peening is a cold working process used to produce a compressive residual stress layer and modify mechanical properties of metals.

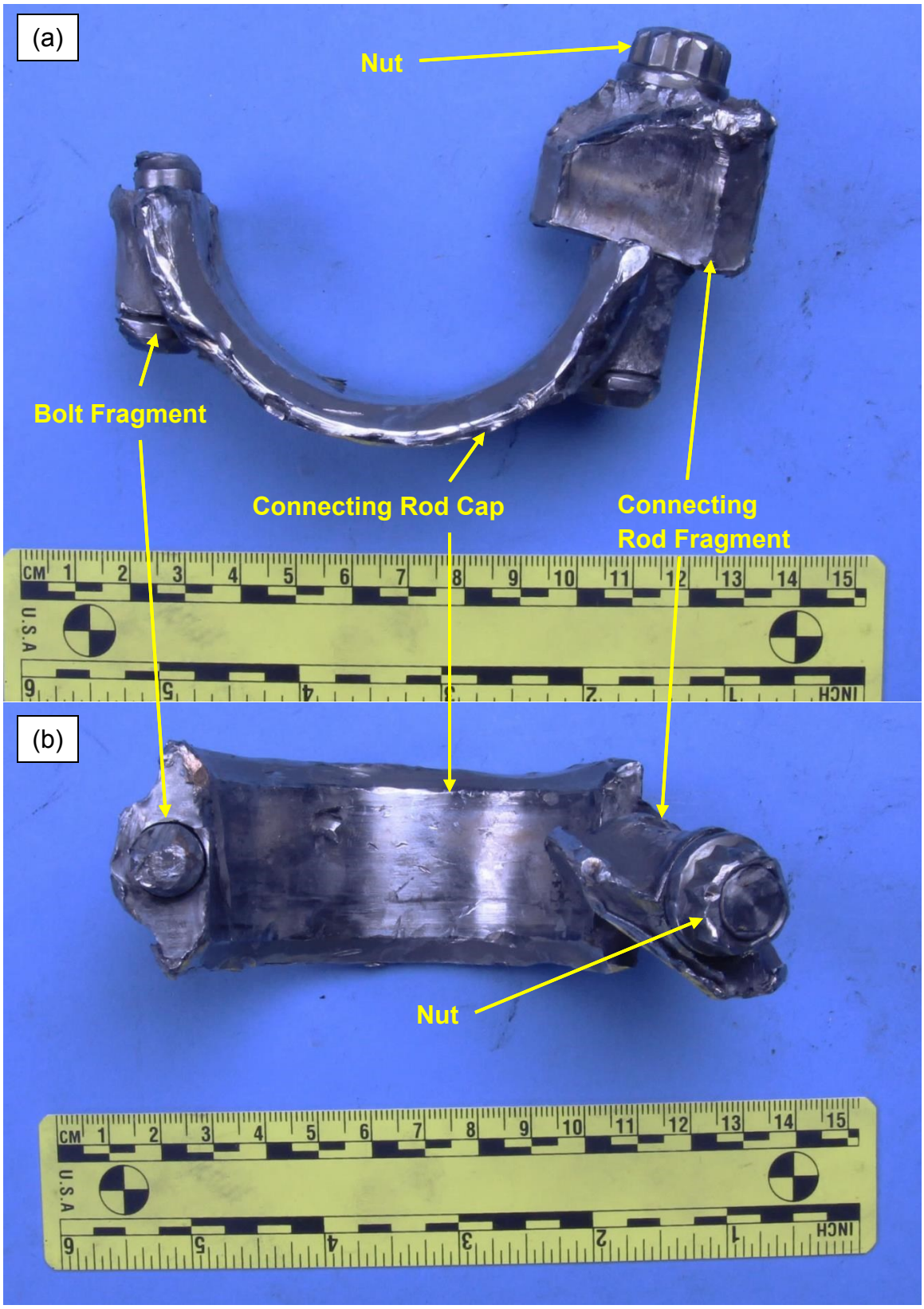

Figure 1 – The connecting rod cap, from (a) the side and (b) the inner race surface.

Figure 2 – The fragment of the connecting rod yoke, showing the fatigue crack.

Figure 3 – Closer view of the fatigue crack in Figure 2, showing clear crack arrest marks with arrows denoting the crack growth direction from the initiation point.

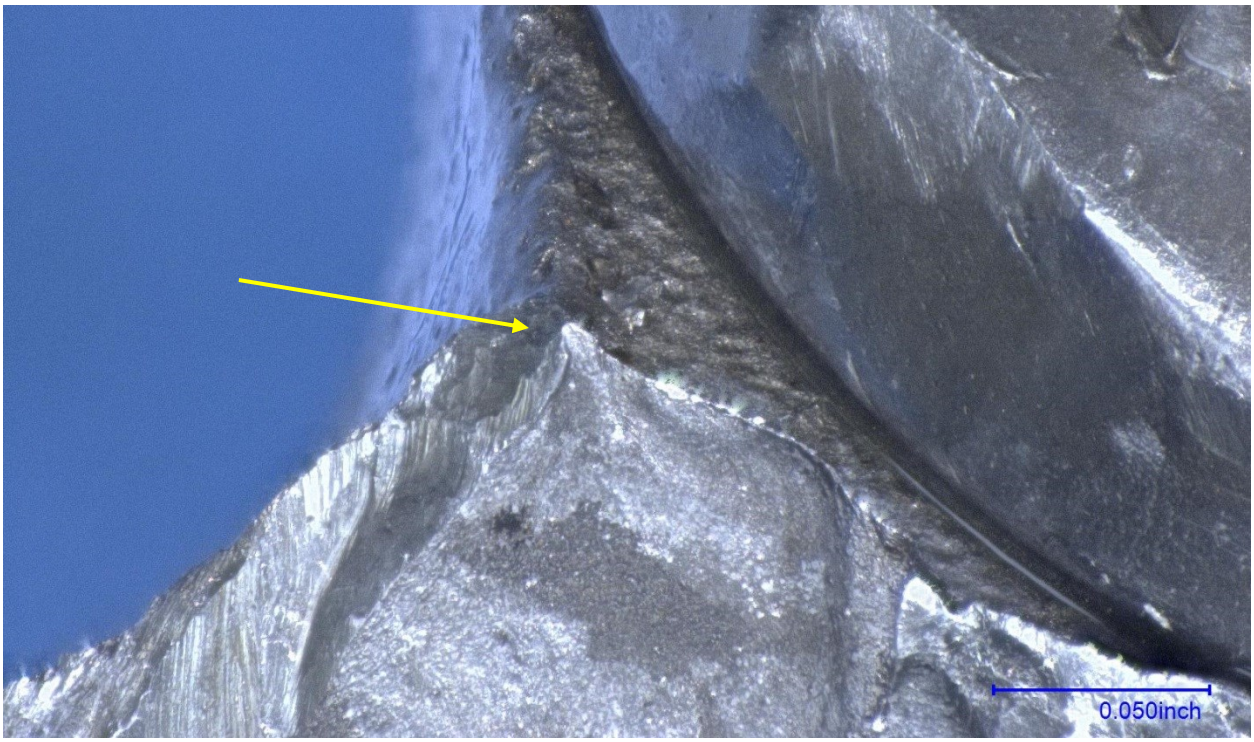

Figure 4 – The crack initiation point (arrow) of the fatigue crack on the connecting rod yoke fragment.

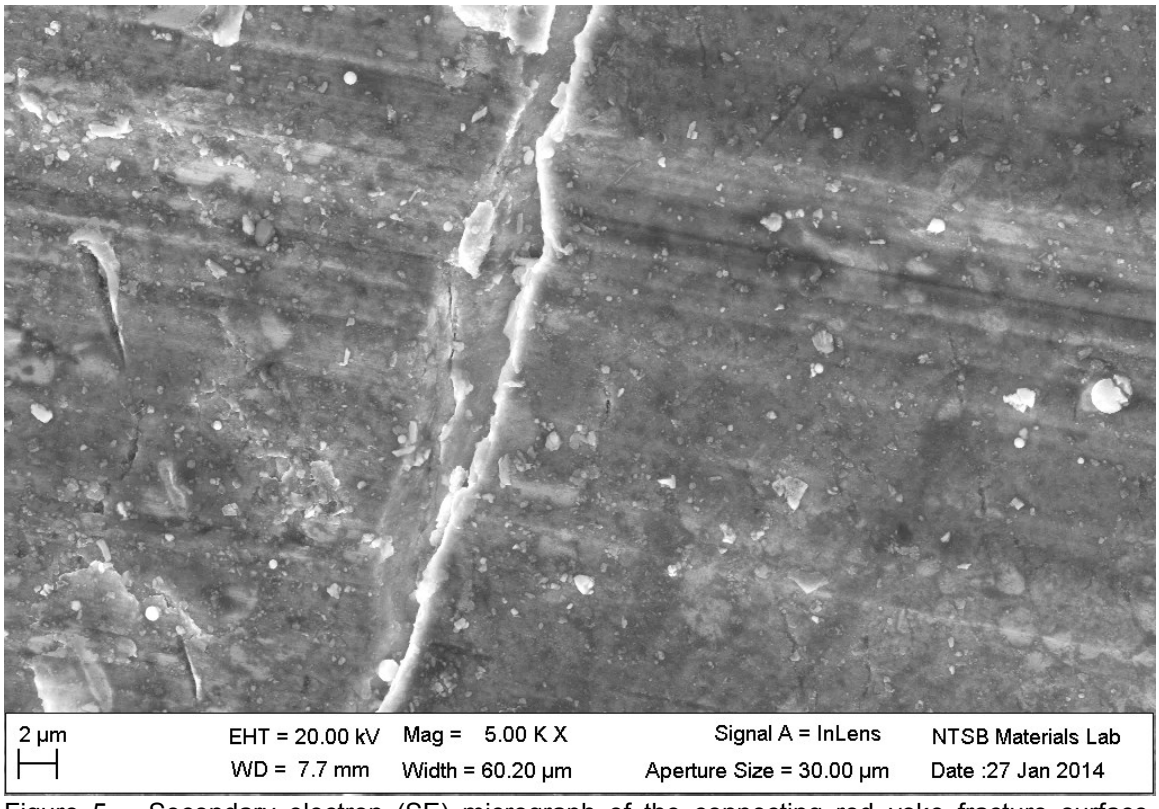

Figure 5 – Secondary electron (SE) micrograph of the connecting rod yoke fracture surface, showing fatigue striations.

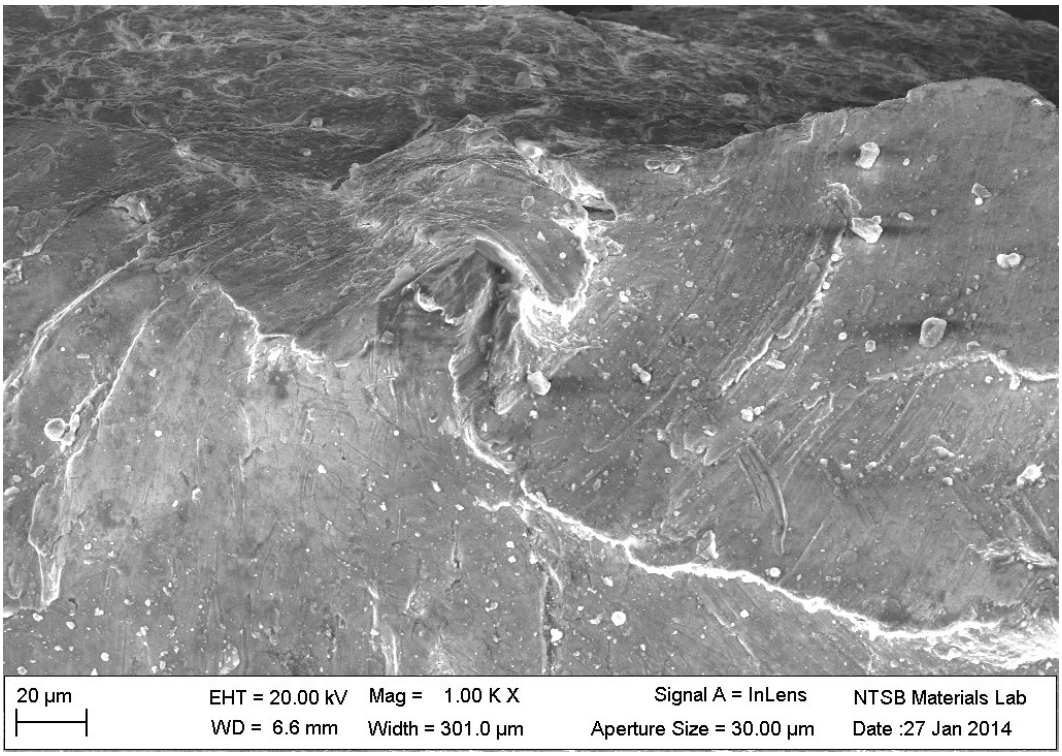

Figure 6 – SE micrograph of the connecting rod yoke fatigue crack initiation site.

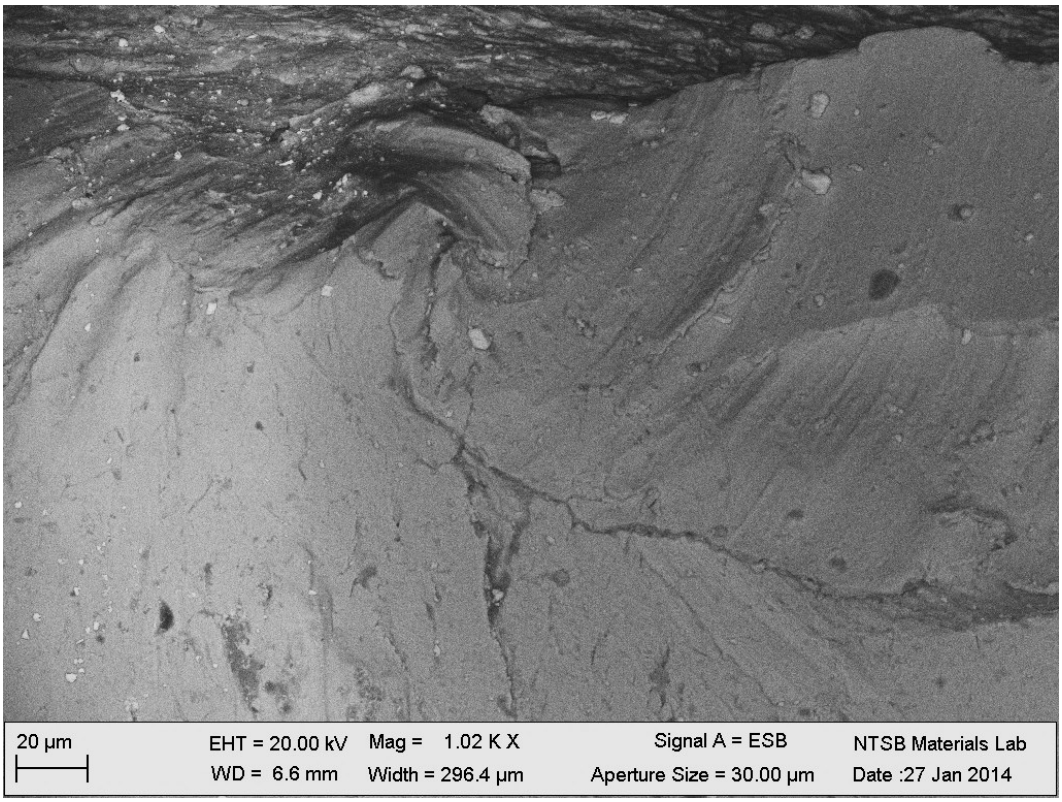

Figure 7 – BE micrograph of the connecting rod yoke fatigue crack initiation site. No foreign material was found at the initiation site.

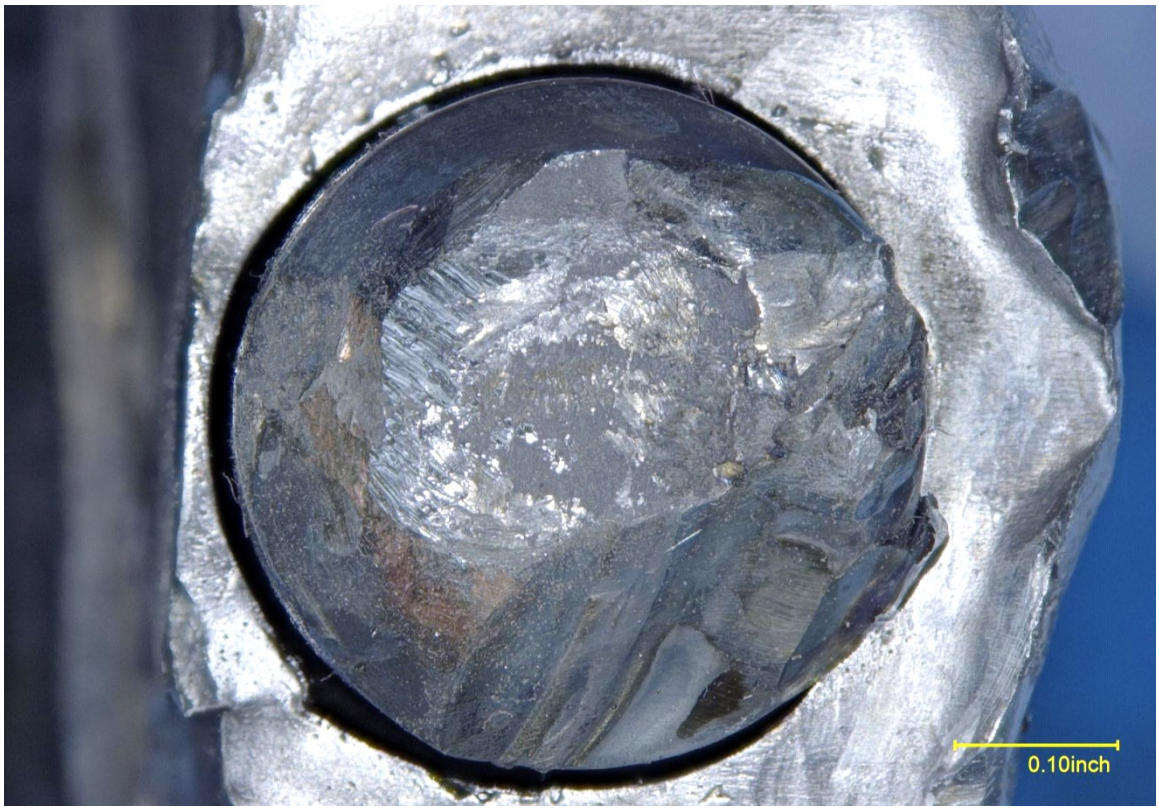

Figure 8 – The fractured end bolt on the connecting rod cap.

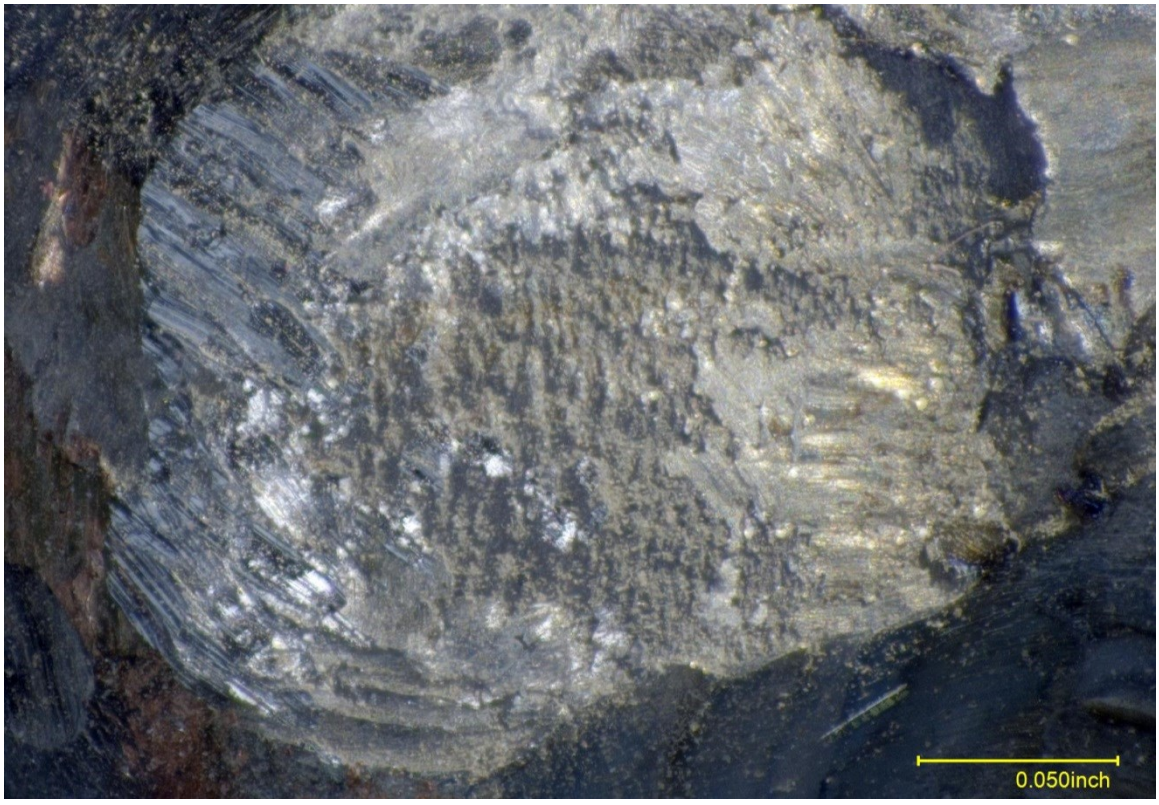

Figure 9 – Closer view of the undamaged fracture surface on the fractured bolt.

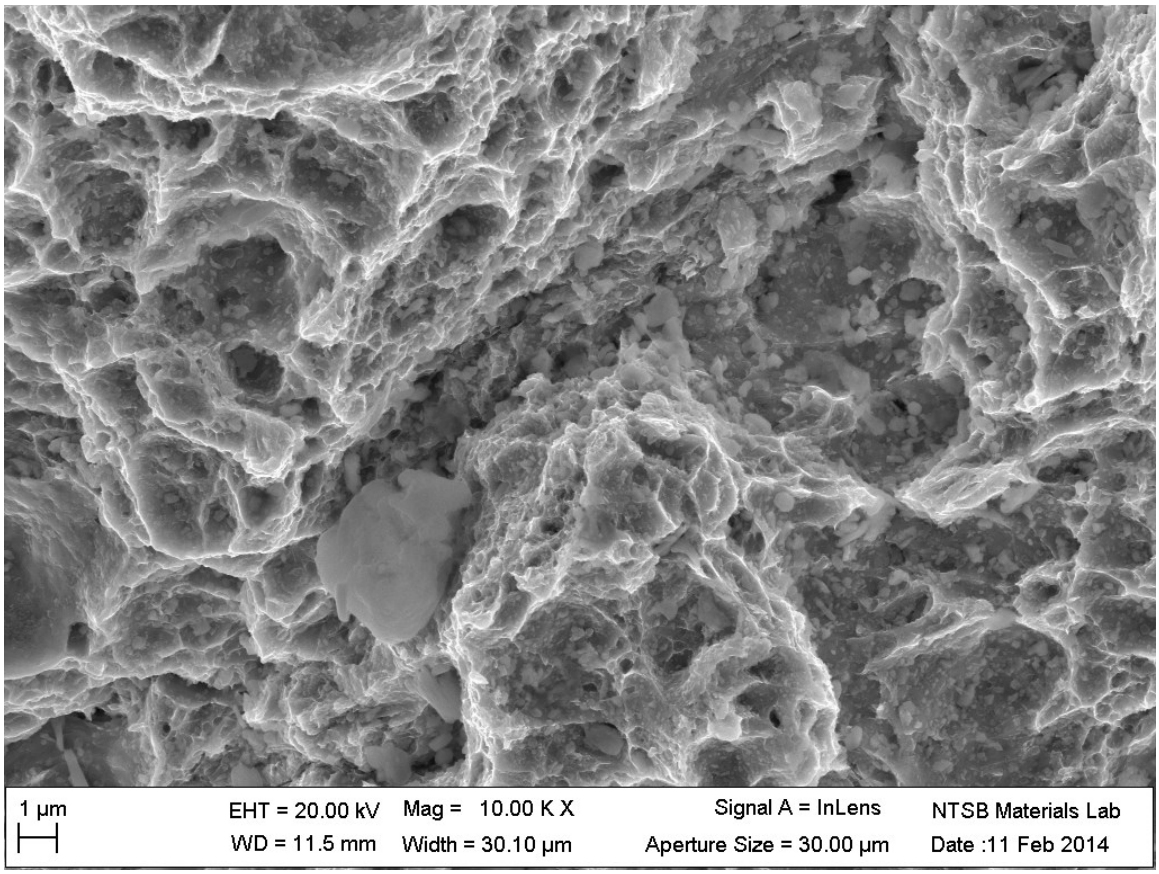

Figure 10 – SE micrograph of the bolt fracture surface, showing dimple rupture indicative of overstress.