

NATIONAL TRANSPORTATION SAFETY BOARD

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



October 15, 2021

MATERIALS LABORATORY FACTUAL REPORT

Report No. 21-078

A. ACCIDENT INFORMATION

Place : Kenansville, North Carolina
Date : January 2, 2020
Vehicle : Cirrus SR22, N323SR
NTSB No. : ERA20LA064
Investigator : Adam Gerhardt, AS-ERA

B. COMPONENTS EXAMINED

Camshaft from a Continental Motors IO-550-N engine.

C. DETAILS OF THE EXAMINATION

An overall view of the submitted camshaft is shown in figure 1. The camshaft was fractured between lobes associated with the number 2 and number 3 cylinders, intersecting oil transfer holes as shown in figure 2. The fracture plane was angled relative to the transverse plane consistent with fatigue fracture under torsion loading.

After an initial examination, a transverse cut was made through the camshaft aft of the fracture location to facilitate further examination of the fracture. After cutting, the fracture surface was submerged in acetone and cleaned using an ultrasonic cleaner. A view of the fracture surface on the sectioned and cleaned piece is shown in figure 3. Relatively smooth fracture features with curving crack arrest lines were observed on the fracture surface, features consistent with fatigue. Crack arrest lines emanated from origins at the corner of the oil transfer hole where it intersected the camshaft exterior surface as indicated in figure 3. Fatigue features were observed around most of the fracture surface, intersecting the oil transfer hole at the opposite side of the camshaft. A portion of the fracture had post-fracture rub damage that obliterated the fracture features in the area indicated in figure 3.

An oblique view of the origin area is shown in figure 4. The exterior surface of the camshaft had a dimpled appearance, consistent with a shot-peened surface treatment. The corner of the oil transfer hole was deformed inward, forming a burr. Dimple features were also observed on the surface of the burr consistent with peening deformation.

The fracture surface shown in figure 4 was examined using a scanning electron microscope (SEM), and images of the fatigue origins are shown in figure 5. Fine fatigue features were obscured or obliterated by fracture surface recontact damage and

oxidation. However, radial features at each origin area emanated from the oil transfer hole corner where the burr was observed. Unlabeled arrows in figure 5 indicate the local directions of fatigue crack propagation away from the corner.

A nonconductive coating was observed on the oil transfer hole and external surface, including the surface of the burr at the corner. The surfaces were analyzed using energy dispersive x-ray spectroscopy, and the resulting spectra showed high peaks of carbon, oxygen, phosphorus, manganese, iron, bromine, and lead, consistent with a manganese phosphate coating on steel mixed with oil and combustion deposits.

The oil transfer hole between lobes associated with the number 4 and number 5 cylinders is shown in figure 6. A burr was observed at the corner of the hole as shown, but no crack was observed upon examination with an optical stereomicroscope. Next, a transverse cut was made through the hole shown in figure 6 along with another parallel cut to produce a section that could be mounted, polished, and etched for metallurgical examination. A metallographic image of the hole corner on the polished and etched cross-section is shown in figure 7. The etched microstructure was consistent with tempered martensite. At the corner where the burr was observed, the microstructure had an elongated texture consistent with surface deformation associated with the burr formation.

The composition of the camshaft material was analyzed using an Olympus Vanta x-ray fluorescence (XRF) alloy analyzer. The material was identified as American Iron and Steel Institute (AISI) 8620 steel, consistent with the expected alloy for the camshaft. While most elements were within the expected compositional range as displayed from the analyzer database, manganese content measured 0.99%, which exceeded the displayed maximum of 0.90% for that element. Additionally, silicon was not detected, which was below the displayed minimum of 0.15% for that element.

The core hardness of the camshaft was measured on the metallurgical cross-section. The average hardness was 43.5 HRC, which is within the expected range of core hardness expected for the camshaft.

Matthew R. Fox, Ph.D.
Senior Materials Engineer



Figure 1. Overall view of the submitted camshaft.



Figure 2. Side view of the camshaft fracture.

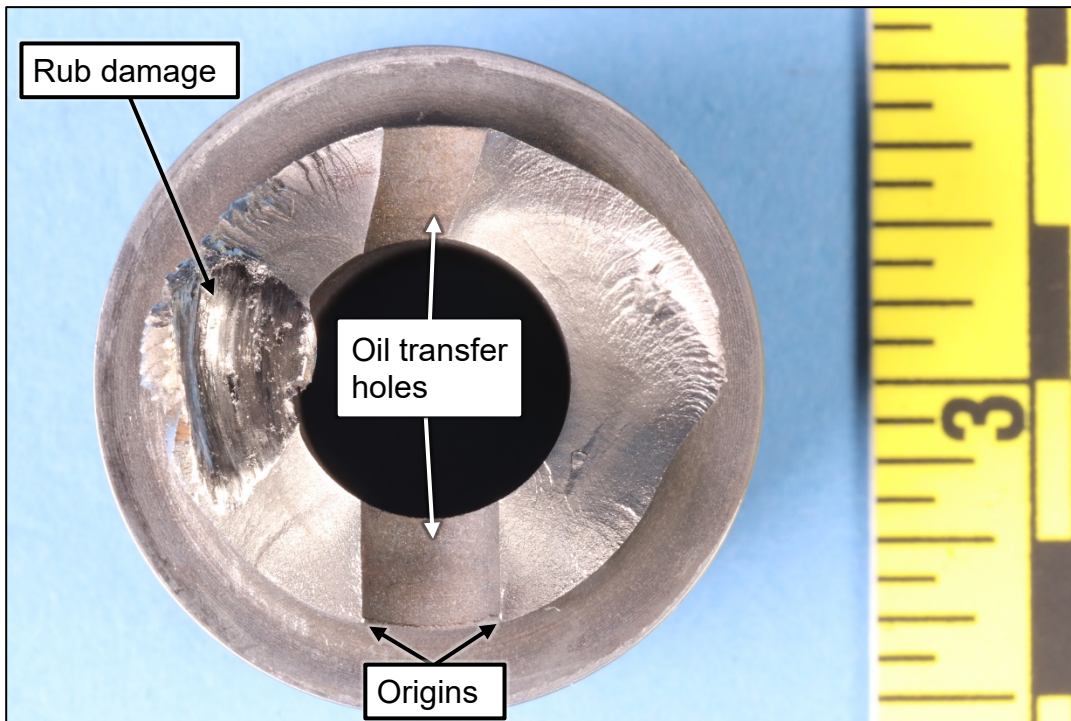


Figure 3. Aft side of the camshaft fracture after sectioning and cleaning.

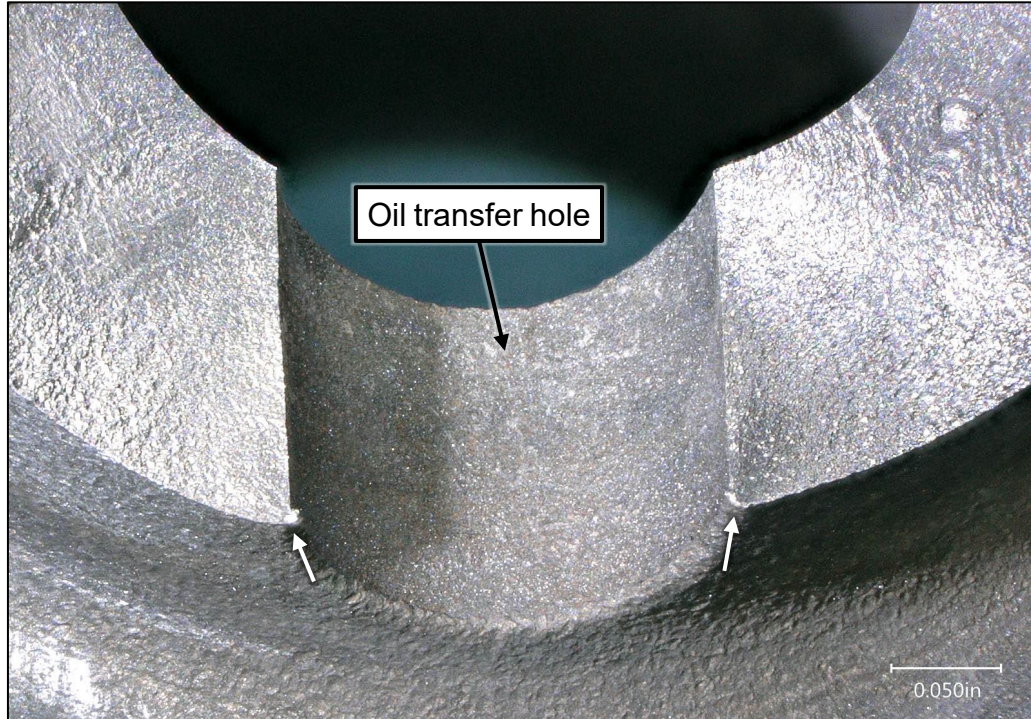


Figure 4. Oblique view of the aft side of the fatigue origin area. Unlabeled arrows indicate origins at the outer corner of the oil transfer hole.

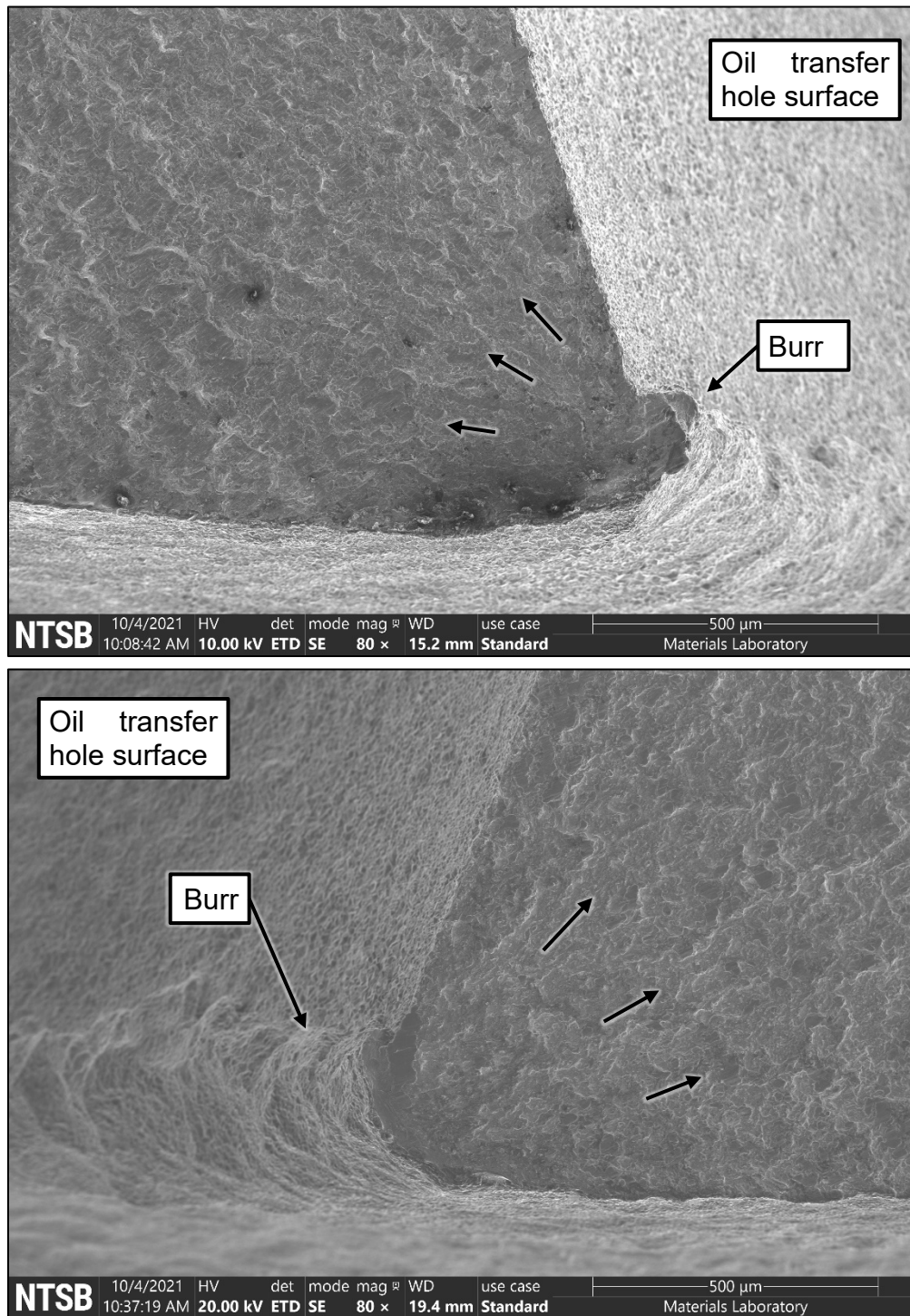


Figure 5. SEM images of fatigue origins at the corner of the oil transfer hole. Unlabeled arrows indicate the direction of fatigue propagation away from the burr at the hole corner.

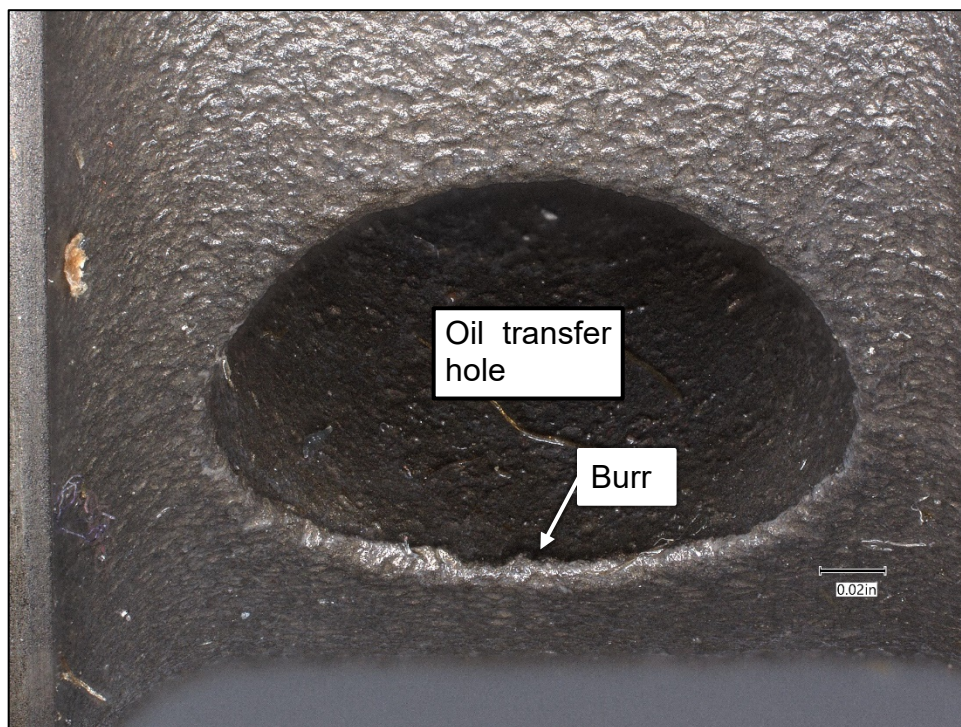


Figure 6. Optical image of another oil transfer hole showing a burr at the corner of the hole.

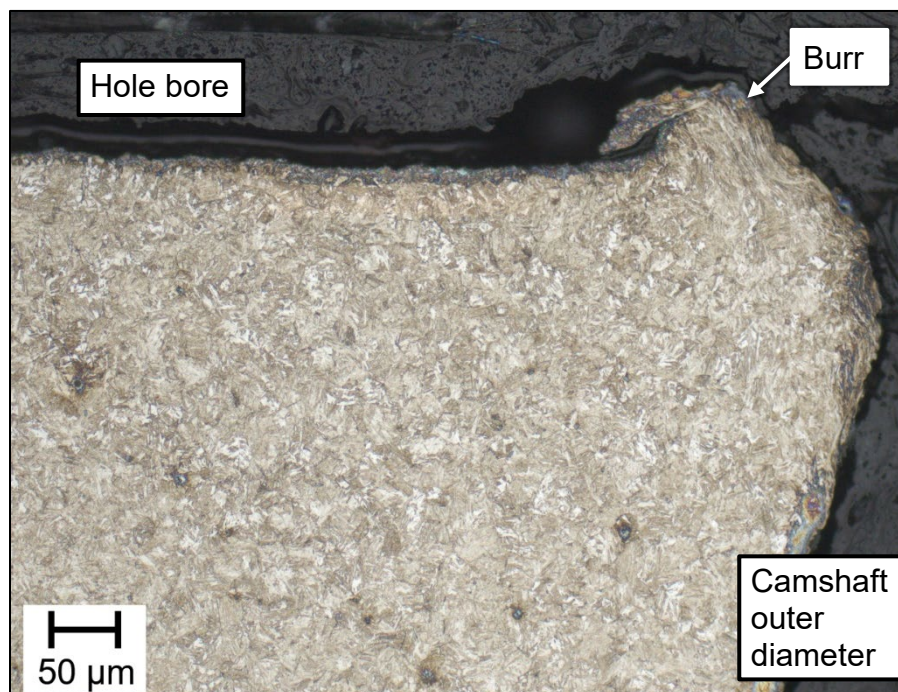


Figure 7. Metallographic image of the hole corner for the oil transfer hole shown in figure 6 (etched with 2% nital).