SAMPLE REPORT No. 3

31 Burnside
Waterlooville
Hampshire
PO7 7QQ
England

Tel: +44 (0)23 9225 4069
Fax: +44 (0)20 8005 1284
Mob: +44 (0)7722 770706

TEST ITEM:
CAMSHAFT FROM THE ENGINE OF A FAMILY MPV CAR
TEST PERFORMED:
FAILURE ANALYSIS

1. INTRODUCTION

A. The camshaft from the subject vehicle was found to have fractured after approximately 29,000 miles service. It was reported that stripping and inspection of the engine revealed no evidence of abnormal service conditions, which could explain the failure.

B. It was requested that an examination of the camshaft should be carried out, in order to determine the cause of failure.

2. WORK CARRIED OUT

A. Visual Examination

(1) After solvent degreasing, the camshaft was examined at magnifications up to x50 using a stereomicroscope. Particular attention was paid to the fracture surfaces and adjacent regions.

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B. **Magnetic Particle Inspection (MPI)**

(1) The shaft was subjected to magnetic particle inspection (MPI). This is a non-destructive crack detection technique, whereby the component is magnetised, either by passing an electric current through it, or by holding it in the magnetic field produced by a coil. Whilst it is magnetised, a fluid containing a fine suspension of fluorescent coated, ferromagnetic particles is flowed over the surface. The edges of any cracks or other discontinuities on the surface act as opposing magnetic poles, thereby attracting these particles. When viewed using ultraviolet light, the cracks become clearly visible as bright lines.

C. **Hardness Testing**

(1) Hardness tests were performed on the cam surfaces and also on one of the bearing journals

3. RESULTS

A. **Visual Examination**

(1) The fracture had occurred approximately 1/3 of the length of the shaft from one end (figure 1). It had initiated on the ground surface of one of the cam lobes but progressed into the radius between two adjacent cams after a short distance.

(2) The initial period of crack growth had produced a shallow trough in the fracture surface (figure 2). Within the trough, the surface was relatively smooth in texture and was considered to be typical of fatigue crack growth. The remainder of the fracture surface was relatively coarse in texture, showing evidence of the as cast microstructure of the shaft. This was considered to be typical of fracture due to static overloading.

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B. **Magnetic Particle Inspection (MPI)**

(1) The magnetic particle inspection revealed numerous microcracks on all of the cam surfaces (figures 3 and 4). The severity of cracking was largely consistent around the circumference of each of the cams. It was apparent that the fatigue crack detailed above had originated from two of these micro-cracks (figures 2 and 4).

C. **Hardness Testing**

(1) The hardness of the cam surfaces on the Rockwell C scale was found to be approximately double that of the bearing journals. This indicated that the cams had been surface hardened during manufacture. No information was available on the specified hardness of the shaft.

4. DISCUSSION

A. The micro-cracks present in the cam surfaces (3.B. above) concentrated the rotating bending stresses applied to the shaft under normal operating conditions. In two of these cracks, the stress concentration was such that the threshold value for fatigue crack growth was exceeded. A period of stable, fatigue crack growth ensued, whereby the crack advanced a short distance with each rotation of the shaft. This produced the trough in the fracture surface (figure 2). As the fatigue crack grew, a point was reached where the stress concentration associated with it exceeded a critical value. At this point, the remaining ligament fractured, due to static overloading.

B. The appearance of the micro-cracks on the cam surfaces was typical of abusive grinding, performed during manufacturing of the shaft. Grinding operations performed either off-centre, with insufficient lubrication, or using excessive feeds and speeds cause frictional heating, which may result in very high surface temperatures. In severe cases, the maximum temperature attained may be sufficient to alter the crystal structure

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of the alloy surface. This produces significant residual stress in the surface, which may result in cracking of the type shown in figures 3 and 4.

5. CONCLUSIONS

A. The subject camshaft failed as a result of fatigue fracture under apparently normal operating conditions. The fatigue fracture had initiated from micro-cracking in the ground surface of one of the cams.

B. The micro-cracking present on the cam surfaces had been caused during manufacture of the camshaft, as a result of abusive grinding.

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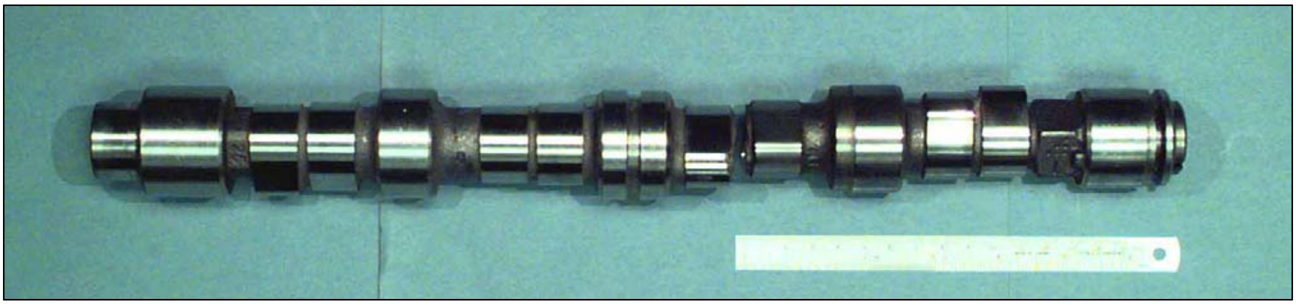

Figure 1 - General view of the fractured camshaft.

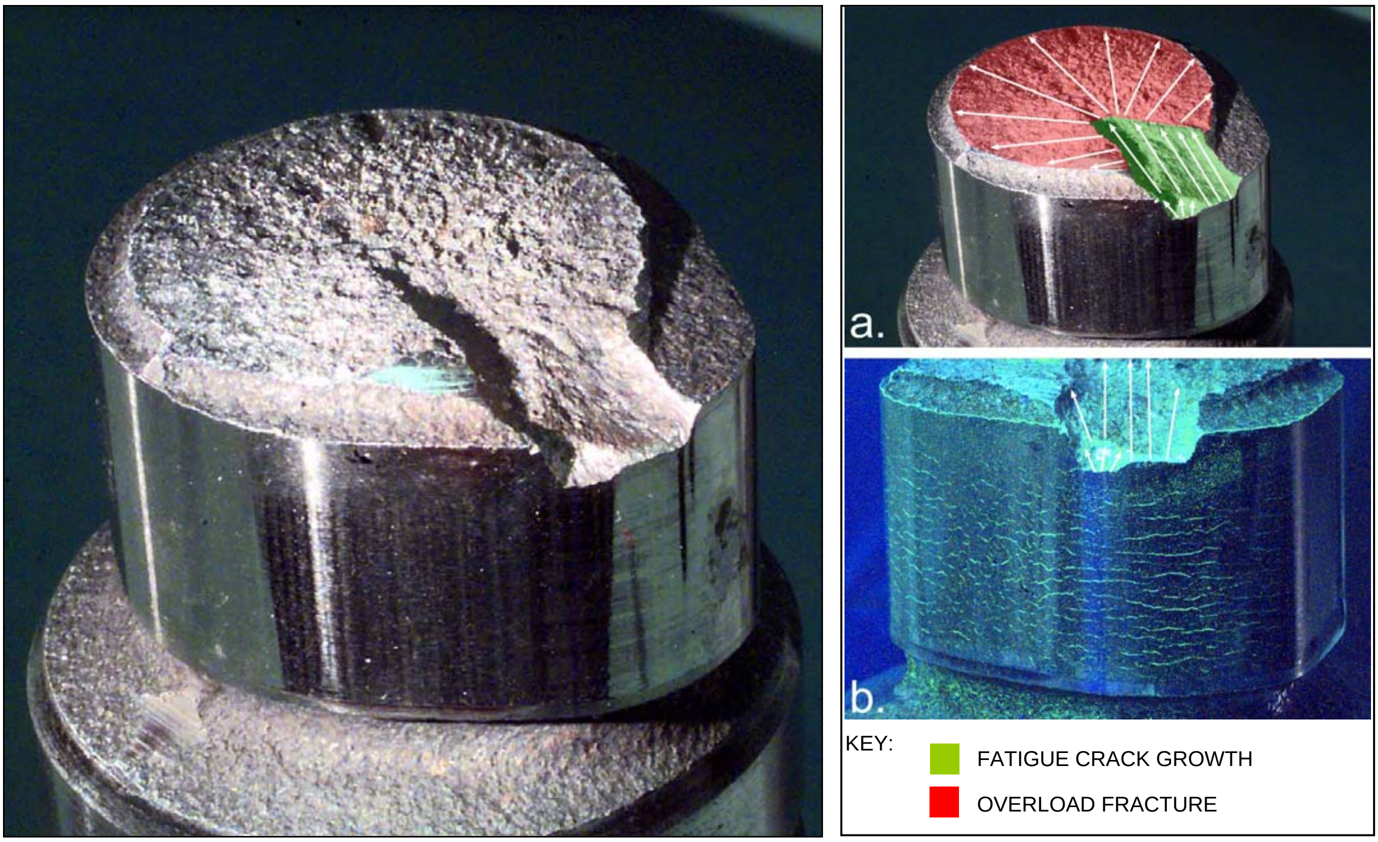

Figure 2 - Close view of the fracture surface.

a. Schematic of the fracture mechanism.

b. Fatigue crack initiation from surface cracking, viewed under ultra-violet light, during magnetic particle inspection.

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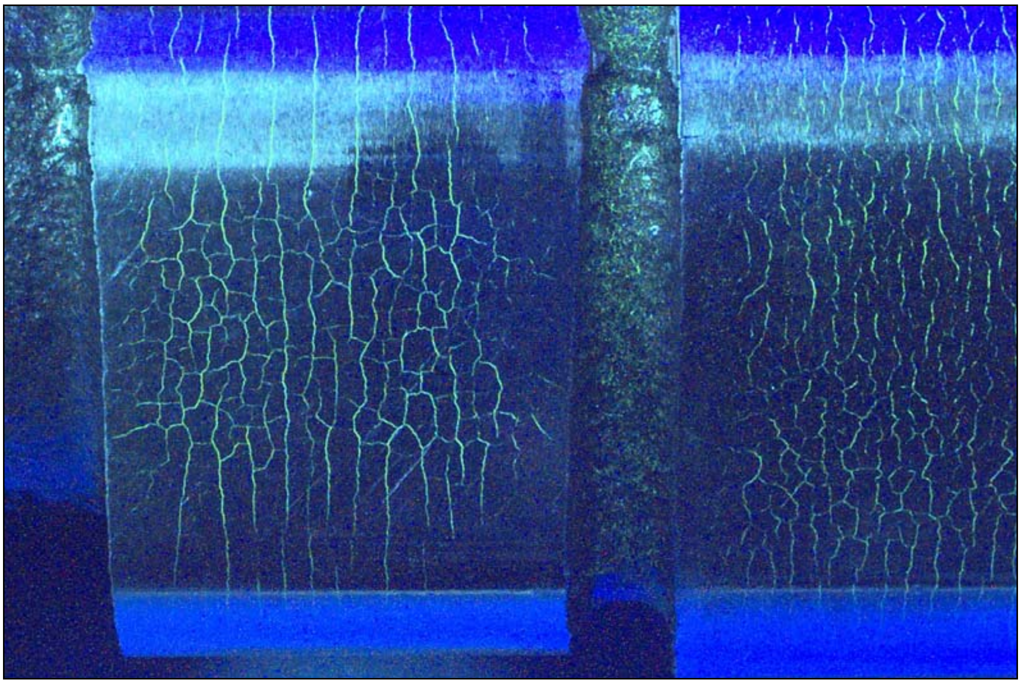

Figure 3 - Close view of surface micro-cracking on two of the cam surfaces, highlighted by magnetic particle inspection.

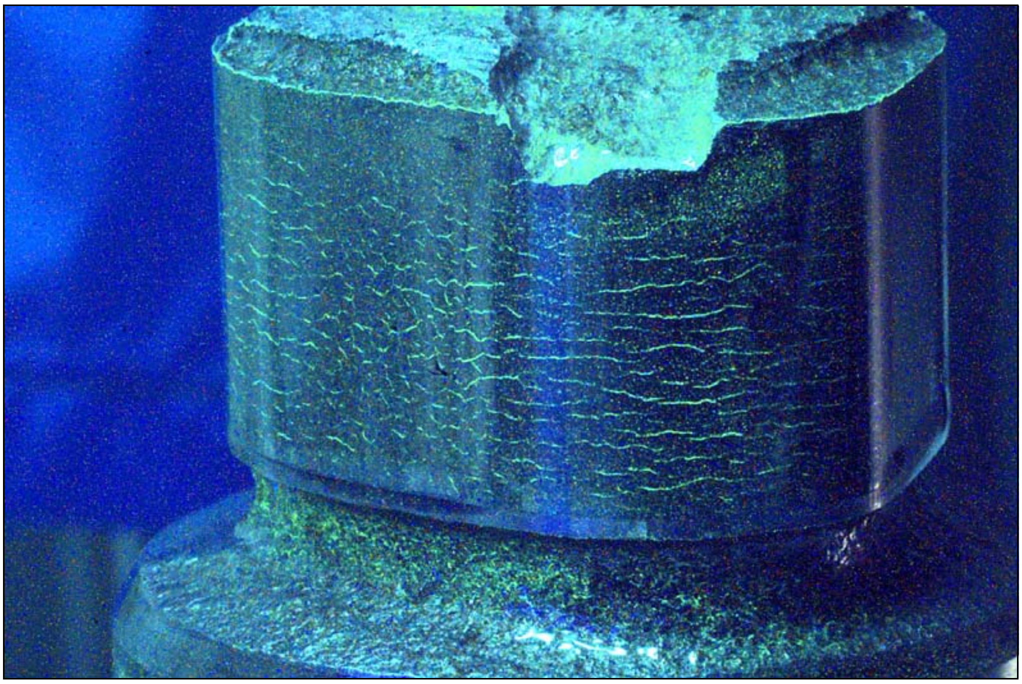

Figure 4 - Close view of fatigue crack initiation from micro-cracks in the ground surface of one of the cams. Viewed under ultra-violet light, during magnetic particle inspection.

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