SPA4. Stress - It Can Happen To You

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Introduction

This poster deals with an example of metallurgical failure investigation of a cracked housing. The housing is shown in Drawing 1 with associated parts. Fatigue failures increase if parts contain stress raisers, such as notches, holes, or keyways. A part may be designed in theory to account for pressure or tensile forces. However, even a small design problem or oversight may lead to premature wear and unsafe conditions. In this case, the design had an oversight in the keyway, which was machined in the inside diameter (ID) of the lower section. The design called for sharp corners in the slot. The sharp corners allowed stress to concentrate and build to the point that caused early failure.

Technical Approach & Results

Aspects of the metallurgical examination of the housing are shown. Drawing 1 shows the design of the housing with key for port alignment. The tool with this housing was initially tested to 15,000 psi. Subsequent tests were done to 10,000 psi. During one test, a leak developed through a crack of this housing.

Figures 1 and 2 show overall views of the housing.

Figures 3 and 4 show views of the crack which initiated from the ID surface at the keyway corner.

The keyway area was removed and opened, (figure 5). A penetrant test, (figure 6), showed the extent of the cracking. A chemical analysis was performed using Energy Dispersive Spectrometry (EDS) on half of the fracture Several contaminants, including sulfur were found on the fracture surface, (figure 7).

Figures 8 through 12 are photographs from a Scanning electron Microscope SEM examination, which showed that the origin area was found to consist of two distinct fracture modes. The first, adjacent to the machined corner in the keyway resembled a short ductile tear, followed by distinctive fatigue striations. After this initial zone, the features became inter-granular for the rest of the fracture. The inter-granular features showed clearly discernable grain faces with no evidence of corrosive attack.

Figures 13 through 16 show photomicrographs of a cross-section of the keyway, confirming origination of the fracture at the bottom of the corner radius.

Figure 15 shows existence of cracking in the other corner of the keyway.

Conclusions

The analysis displayed three different types of fractures:

1. a ductile tear
2. a short fatigue crack
3. inter-granular cracks

Drawing 2 shows two revisions to the housing and keyway made in order to reduce the stress on the keyway corner.

- A larger radius was determined for the keyway housing and corners.
- The material of the key was changed from steel to the same material has the housing.

Since these changes have been instigated, no further cracks in the housing have been detected.