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Failure Analysis of a Tie Rod due to Impact

Keywords: Tie Rod, Fracture, Bending, Impact

Material: Steel

Introduction

A fractured tie rod, the subject of the above referenced caption, was submitted for failure analysis to determine the cause of fracture. It was reported that 'The assured, while driving in New York, suddenly heard a "pop", and lost control of the car. Inspection of the area of the accident discloses no pot holes or repairs to the pavement. Upon hearing the popping sound, wheel steering was rendered useless. Visual examination, mechanical and metallographic analyses was performed on the submitted boiler sections to look for root cause of the failure.

Visual Examination

Figure 1 is a photograph of the subject tie rod end as it appeared when submitted. Failure had taken place at the last thread from the threaded end of the tie rod. It is apparent that failure was caused by severe bending forces which first caused almost right angle bend in the tie then fracture. The compression of threads on the concave side and the stretching of the thread on thee convex side are evident. The root of the thread adjacent to the fracture was also observed to have been cracked on the convex side. Figure 2 is a close—up photograph of the mating fracture surfaces. The fracture surfaces are decidedly due to bending with tensile failure starting at the convex side of the bend and progressing across the tie rod cross—section to the concave side which experienced first compression and then tension. Moreover, the facture texture is indicative of bending overload failure. No evidence of any defect was found in the fracture surfaces.

Fig 1 Fracture tie rod as received condition

Fig 2 Close look of fracture surface

Mechanical Test

A flat surface was ground on the tie rod shaft in order to determine general hardness of the shaft with result showed following:

Hardness	Result
Rockwell	C29

Rockwell C29 indicates a tensile strength on the order of 132,000 psi for the tie rod material

Microscopic Examination

Two samples were cut from the long section of the tie rod at the fractured end. The first sample which was approximately one-half inch long and containing fracture surface was used for a scanning electron microscopic (SEM) study. The second, taken adjacent to the first was for light microscopic examination of the tie rod microstructure. This latter examination

revealed the rod to be a steel in the heat treated (quenched and a tempered) condition with a tempered martensitic microstructure. Figure 3 a photo— micrograph (5OOX) showing this structure which is normal for a hardened steel. A small band of decarburization was observed at the tie rod surface but this is not considered a factor in the failure of the tie rod.

Scanning electron microscopic examination of fracture surface on the sample cut from the long section of the rod uncovered no evidence of any defect in the material. Similarly, no evidence of progressive (fatigue) failure was found. What was observed was a failure mode typical of overload of a sound, ductile material. That is, the fracture texture was what is commonly called a “dimple" structure. This is shown in 4 which is a SEM fractograph (1000X) of an area on the fracture surface. The SEM finding confirm what was observed by visual examination and stereomicroscopic examination.

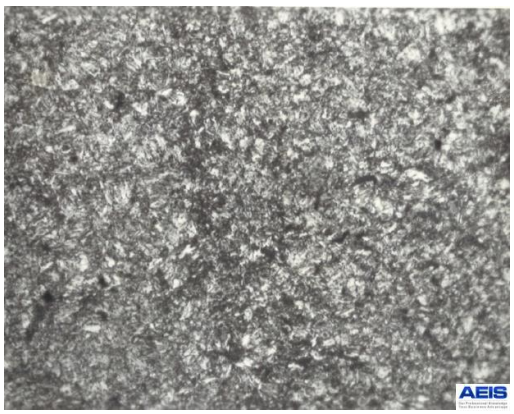

Fig 3 Microstructure of fractured tie rod X500

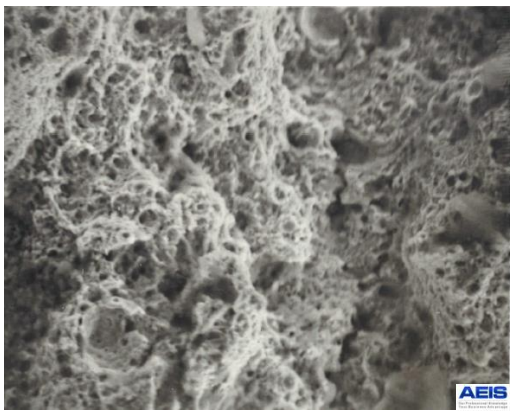

Fig 4 SEM image of fracture surface X1000

Conclusion

The rod was found to be sound and normal with no evidence of any material or manufacturing defect observed. Failure of the tie rod end was caused by severe bending loads which resulted in both bending deformation and ultimate fracture. This type of failure is typical of that caused by impact.