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# Fractography of the fracture surface of a Small Tube

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## 1. Introduction

Power plants have a great number of components that are used in high-temperature environment. As they are used under severe environment, theycan easily become aged and degraded. This paper provides fractography analysis of damaged small tubes.

## 2. Leak-Off Lines (Small Tubes)

Leak-Off Lines are monitoring tubes that are installed in a high-pressure tank. They monitor for the leakage of cooling water. Figure 1 shows the location of damaged tubes. Table 1 shows the property of these tubes.

Table 1. Tube Property

| | |
|---|---|
| Material | ASTM A213 TP 304 |
| OD | 12.7mm |
| Thickness | 1.65mm |

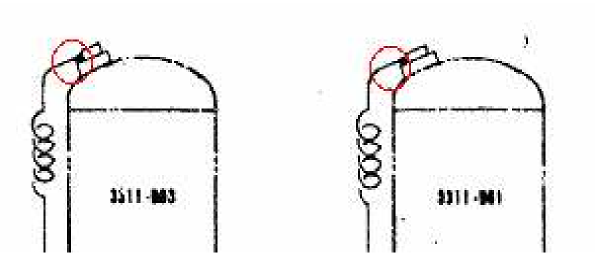


Fig. 1 Location of the damaged tube

## 3. Fractography of the Fracture Surface

### *3.1 Macro-scope Observation*

Figure 2 shows a damaged tube under observation using macro-scope. In Fig. 2, a crack was propagated at 30° in a section. In this case, the crack section is very sharp, as this tube experienced brittle fracturing.

Figure 3 shows the fatigue fracture for combined stress [1]. In Fig. 3, θ denotes $\tan\theta = \sigma/2\tau$, the point at which the tensional cyclic load and torsional cyclic load was applied the specimens: the fatigue fracture angle was θ=0° and θ=90°, respectively, for these two loads. The crack propagation angle is 30° in the damaged tube is similar to the fatigue fracture angle of $\theta$=45° in Fig. 2. If $\theta$=45° for the combined stress, the stress ratio is $\sigma/\tau \fallingdotseq 1.7$. Based on the result shown in fig. 3, it can be considered the damaged tube was cracked by combined stress (tensional and torsional cyclic stress) and that the tensional cyclic stress was larger than the torsional cyclic stress by 1.7 times.

Fig. 2 Damaged tube

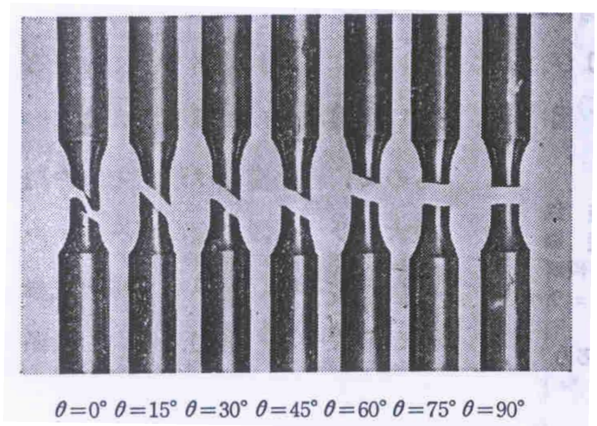



Fig. 3 Fatigue fracture for combined stress
($\tan\Theta = \sigma/2\tau$ , $\sigma$ : tensional stress, $\tau$ : torsional stress)

### *3.2. Micro-scope Observation*

#### *3.2.1 Removal of Corrosion Product on Fracture Surfaces*

As the tubes were damaged under long-term use, the fractured surface of the tube was covered with corrosion. Initially, macro-scope observation was conducted and micro-scope observation was then conducted after the removal of the corrosion.

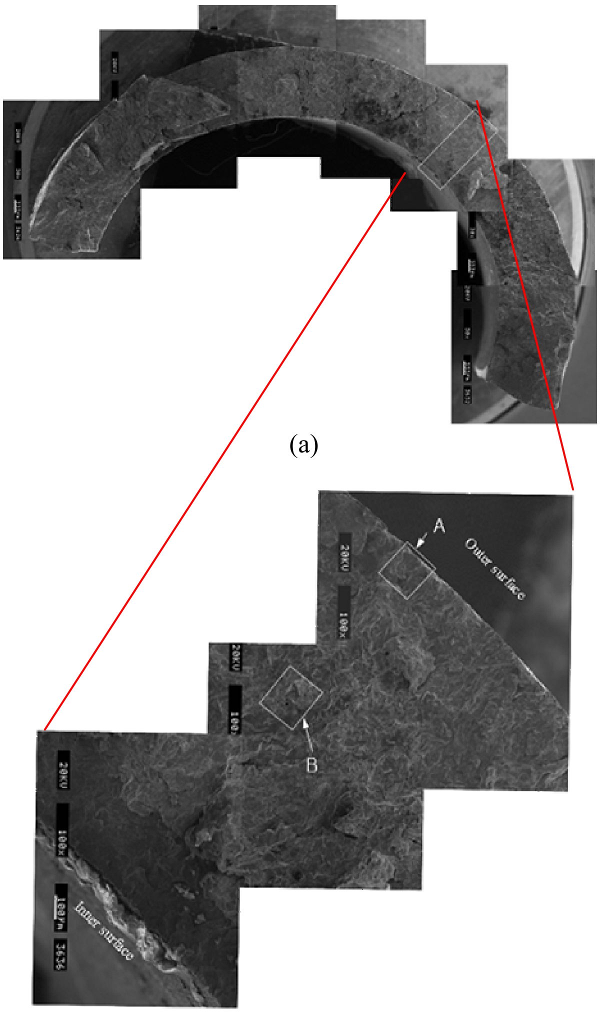
The chemicals used to remove the corrosion are shown in Table 1. After removing this corrosion using an ultrasonic cleaner, the chemicals were neutralized by using ammonia water.

Table 1 Chemicals

| Chemicals | Purity | Dose |
|---|---|---|
| Inhibitor (#2S) | 0.5% | 50ml |
| Ascorbic acid | 0.5% | 50ml |
| HCl | 5% | 1350ml |

Figures 4 (a) and (b) show an image of the fracture surface taken by a SEM (Scanning Electron Microscope). In Fig. 4 (a), a secondary crack can be observed on the fracture surface. There are no share lip and plastic deformation on the fracture surface. The crack origin on the fracture surface was not determined. In Fig. 4 (b), the outer surface has more flat compared to inner surface.

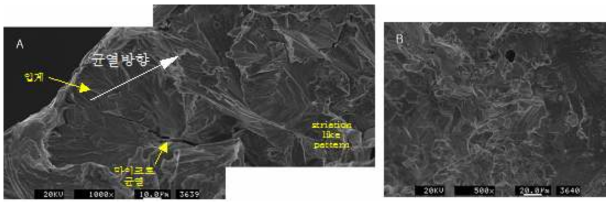
Figure 5 shows a magnified picture of Fig. 4. The cleavage fracture that is part of a transgranular fracture is shown in this figure. Again, there is no plastic deformation [2]. In Fig. 5 (a), a striation-like pattern is shown. Generally, striation is evidence that a component was damaged by a tension cyclic load. However this tube was damaged by both tensional and torsional cyclic loads; thus, striation was not observed.




(a)

(b)

Fig. 4 The fracture surface of the tube




(a) (b)

Fig. 5 A magnified image of Fig. 4

## 4. Conclusions

The main results obtained in this study are summarized as follows:

(1) A small tube was damaged by tensional and torsional cyclic loads.
(2) The fracture origin was not determined on the fracture surface.
(3) There was no striation on the fracture surface.

## REFERENCES

[1] Fatigue and design of materials, Koumoto, Corona, Japan, 1980
[2] Fractograpgy of a fracture surface, Technoeye, Japan, 1985