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Studies on the thermal fatigue crack of STS 304 tube

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1. Introduction

For the continuous operations of nuclear power plants all system components must not fail during operation. It is very important to find out the damages of the system components in its initial stage. For that purpose it is strongly needed to have mock-up specimens which contain similar damages in different positions.

Until now it was very difficult to produce thermal fatigue cracks on the inner surface of stainless tube.

In this study, the results of two kinds of fatigue crack production are presented. Mechanical and thermal fatigue cracks are produced on the STS 304.

Mechanical fatigue cracks are produced at base metals and welded metal using STS 304 flat bars. Thermal fatigue cracks are produced on flat bars and tubes. Thermal fatigue cracks, generated on the inner surface of the tubes, propagate from inside to outside. Mechanical and thermal fatigue crack geometry and their fractographic morphologies are briefly presented.

2. Methods and Results

2.1 Experimental Method

2.1.1 Block diagram of fatigue crack producing apparatus

In order to produce mechanical fatigue crack, we used a plate 240×25×6 (mm) that has a notch of 0.3mm depth in its center. The producing mechanism of fatigue crack is shown Figure 1.

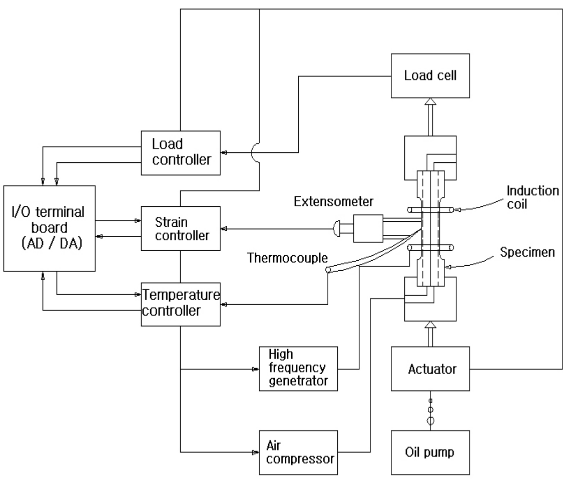

Figure 1. Mechanism of fatigue crack formation

2.2 Experimental Results

2.2.1 Fatigue crack

Figure 2 (a) shows the surface morphology of mechanically produced fatigue crack and 2 (b) its fracture surface.

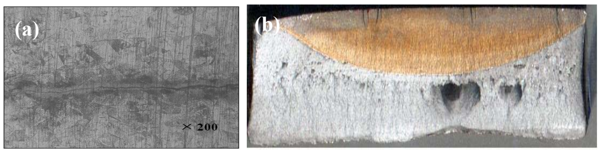

Figure 2. The crack by mechanical method (a) fatigue crack (b) fracture surface

2.2.2 Thermal Fatigue Crack

Small notch was applied on STS 304 tubes with 89mm O.D. (t = 7.7mm) and periodic change of temperature was applied on the notched area. For heating up to 550℃ HF induction heating coil was used. Applied thermal differences are about 300℃.

In Figure 3 (a) and 3 (b), a macro section and crack surfaces of thermal fatigue cracks are shown. It is clear to see that the crack was initiated from the notch and propagated from inside to outside.

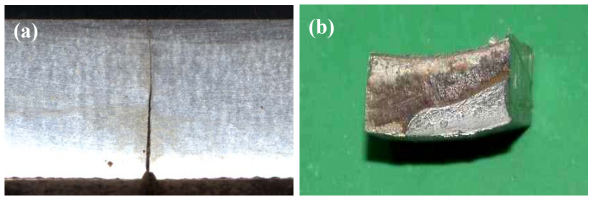

Figure 3. The crack by thermal stratification method (a) Thermal fatigue crack (b) fracture surface

2.2.3 Fractographic morphology of fatigue cracks

Figure 4 (a) and (b) show SEM fractographic of mechanical fatigue crack and thermal fatigue crack.

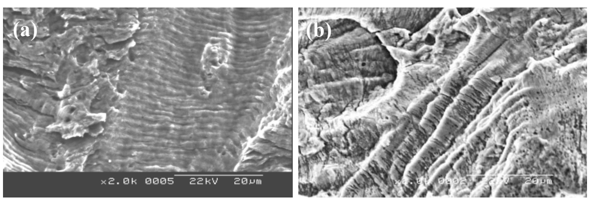

Figure 4. SEM fractographic of mechanical and thermal stratification method (a) Mechanical fatigue crack (b) Thermal fatigue crack

Characteristic microfractographic appearance of fatigue crack surfaces is shown in both Figure 4 (a) and (b). Although the maximum temperature was 550℃, oxide layers are formed on the surfaces of thermal fatigue cracks (Figure a (4)).

3. Conclusion

Two kinds of fatigue cracks (mechanical and thermal fatigue cracks) are artificially produced on STS 304 in order to produce mock-up specimens for the NDT of nuclear power plant components.

1. It is possible to produce a mock-up specimen for the test of thermal fatigue cracks on STS 304 tube. Thermal fatigue cracks are propagated from inner surface to outer.

2. With 300℃ of ΔT (temperature difference of bottom parts in tube), cracks were initiated after about 14000 thermal cycles.

3. With higher number of cycles (24,000 cycles), cracks are propagated to outer surface.

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