Study on the fabrication of the Stress Corrosion Crack by vapor pressure in the Alloy 600 Pipe

Jae-Seong Kim,a Ju-seon An,a Woong-Ki Hwang,a Bo-Young Lee,b
NRL for Cracking Control and Management,
a department of Aerospace and Mechanical Engineering,
b faculty of Aerospace and Mechanical Engineering,
Korea Aerospace University, Goyang-city, 412-791, Kyunggi-do, Korea

1. Introduction

The stress corrosion crack is one of the life-limiting mechanisms in nuclear power plant conditions. During the operation of a power plant stress corrosion cracks can initiate and grow in dissimilar metal weld pipe joints of primary loop components. In particular, stress-corrosion cracking usually occurs when the following three factors exist at the same time; susceptible material, corrosive environment, and tensile stress (including residual stress). Thus, residual stress becomes very critical for stress-corrosion cracking when it is difficult to improve the material corrosivity of the components and their environment under operating conditions [1,3]. Since the research conducted by Coriou et al.,[2] it is well known that Ni-based alloy is susceptible to stress corrosion cracking(SCC) in deaerated pure water at high temperature and the SCC is difficult to be reproduced in laboratory.

The aim of this study was to fulfill the need by developing an artificial SCC manufacturing method, which would produce realistic SCC in the Alloy 600 pipe.

2. Methods and Results

2.1 Experimental Method

2.1.1 Block diagram of stress corrosion crack producing apparatus

The test material was austenitic STS 304, which is used as pipelines in the Reactor Coolant System of a nuclear power plants (O.D.= 89mm, t=7.7mm). The fabricating mechanism of the stress corrosion crack formation is shown Fig. 1.

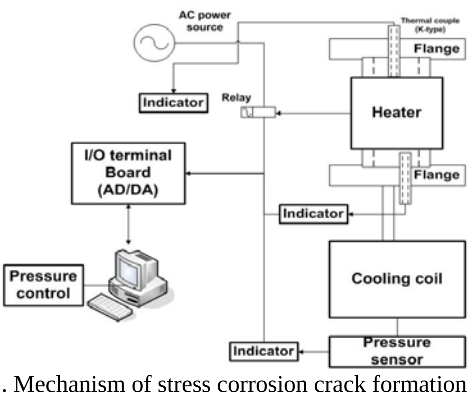

Figure 1. Mechanism of stress corrosion crack formation

SCC tests were performed using the alloy 600 pipe in Na_2SO_4 and NaOH solutions. The length of specimen is 150mm. The welding machine was used for giving the residual stress. Table I shows chemical composition and mechanical properties of the alloy 600. To generate vapor pressure in the inner pipe during the test, the pipe was heated by the heating coil.

Table I: Chemical composition and mechanical properties of alloy 600

Element	C	Mn	Fe	S	Si	Ni	Cr
Composition	0.03	0.21	9.49	0.001	0.12	73.85	16.2
Yield strength(MPa)		Tensile strength (MPa)			Elongation (%)		
339		683			45.4		

3.2 Experimental results

3.2.1 Temperature and pressure

The stress corrosion crack was fabricated using the custom-made manufacturing system. Fig. 2 shows a temperature and pressure during test. The vapor pressure was decreased after about 5 hour. This means that the crack was already manufactured by residual stress or solutions before decreasing vapor pressure.

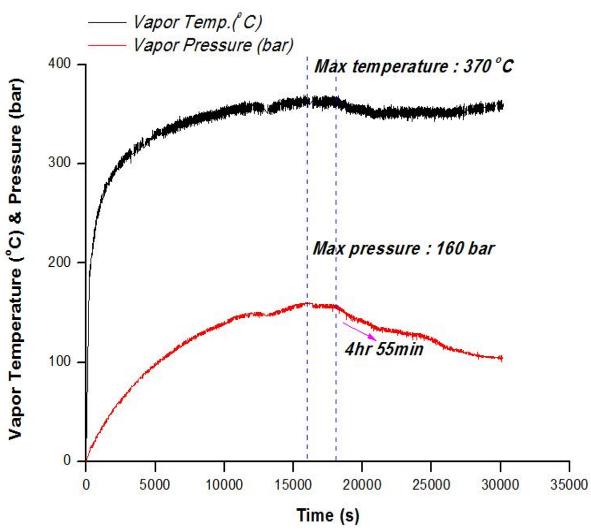

Figure 2. Temperature and vapor pressure inner pipe

3.2.2 Stress Corrosion Crack

Fig. 3 shows the visual and PT test of the top and bottom inner surface in the pipe. Many cracks were observed in the inner pipe.

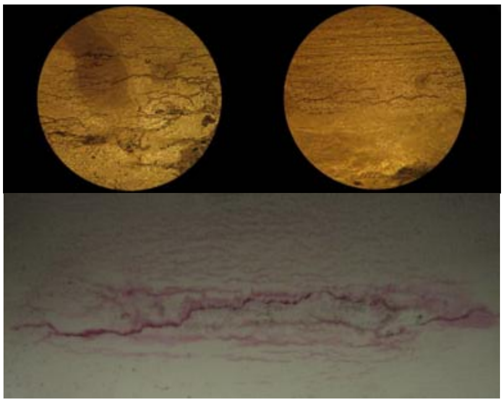

Figure 3. The results of visual and PT test (TOP inner in the pipe)

3.2.3 Fractography

Fig. 4 shows the OM fractograph of the inner surface pipe. It is confirmed that the cracks were propagated according to grain boundary. The IGSCC are clearly revealed.

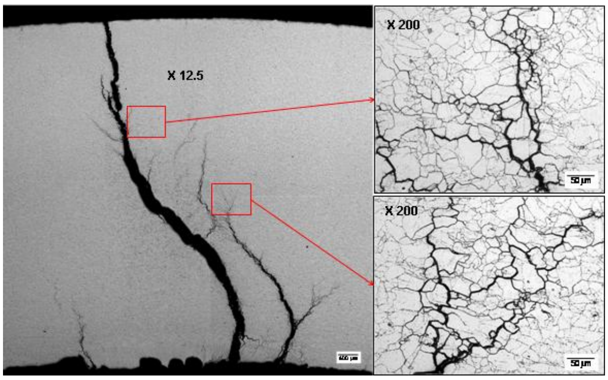

Figure 4. Fractography of the SCC

4. Conclusion

In this study, stress corrosion crack was artificially produced on alloy 600 pipe. It is confirmed that the cracks were propagated according to grain boundary. The intergranular stress corrosion cracks are clearly revealed. The new system was developed directly for manufacturing stress corrosion crack in the inner surface of the pipe.

5. Acknowledgments

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