

Influence of Corrosion Environment on SCC Behavior of SUS304 in H₂SO₄-NaCl Aqueous Solution

Satoshi Sunada, Akira Motozawa and Kazuhiko Majima
Department of Material System Engineering and Life
Science, Faculty of Engineering, Toyama University
Gofuku 3190, Toyama, 930-8555, Japan

It is well known that austenitic stainless steels are subjected to various corrosion attacks when they are used under severe conditions. Among corrosion attacks, stress corrosion cracking (SCC), is one of the aggressive corrosive attacks, and it sometimes results in serious accidents, because SCC propagates deep inside to decrease the strength of the material even though the degree of corrosion is small. It is recognized that in the aqueous solution of H₂SO₄ containing NaCl of a specific concentration range, the initiation of SCC is enhanced, while in the solution of other concentration range, only general corrosion occurs. However, most of the past works carried out on the aqueous solution of H₂SO₄ containing NaCl have reviewed only the influence of environmental factors on the initiation, susceptibility and rupture time of SCC. Few works have been made on the corrosion type including SCC. In this experiment, therefore, the influence of corrosion environment on the corrosion type was investigated using aqueous solutions composed of 0.5-5.5 kmol/m³ H₂SO₄ and 0.1-0.5 kmol/m³ NaCl.

The SUS304 stainless steel specimen with the dimension of 50 mm long, 15 mm wide and 2 mm thick was polished with No. 2000 grit water-proofed abrasive paper followed by washing in alcohol and subsequent ultrasonic rinsing in acetone. Bending load was applied to the specimens by three points beam method using a polyvinyl chloride resin bender. The specimens together with the bender were immersed in the corrosive solution kept at 303 K for 259.2 ks. After the immersion test, the cross section of the specimen was polished to a mirror surface with No.2000 grit water-proofed abrasive paper followed by buffing. Then, the specimen was subjected to electropolishing in a solution of 70 % HNO₃ and 30 % CH₃COOH at 10 V for 15 s, and SEM observation. To clarify the influence of potential on the corrosion behavior, SCC testing was performed under constant potential. The

specimen electrode was made by coating it with silicon rubber leaving uncoated area of 15 x 5 in mm for the exposed surface. The test solution used was aqueous solution of 2.5 kmol/m³ H₂SO₄ containing 0.2 kmol/m³ NaCl. After stress was applied, the specimen was kept in the corrosive solution for 172.8 ks under the constant potentials in the range from cathodic -0.410 V to anodic 0.000 V. The potential was referred to an Ag-AgCl reference electrode.

In any H₂SO₄ solution of 0.5-5.5 kmol/m³ without NaCl, no SCC was observed. In the solution of 0.5 kmol/m³ H₂SO₄, neither SCC nor intergranular corrosion was observed when the concentration of NaCl was 0 or 0.1 kmol/m³. Cracking peculiar to SCC was observed along grain boundaries and inside the grains when the NaCl concentrations were 0.2, 0.3, 0.4 and 0.5 kmol/m³, which indicates that the corrosion type of transgranular SCC worked. In this case, it was also recognized that the more NaCl was added, the deeper the cracking grew. In the case of 1.5 kmol/m³ H₂SO₄, SCC was observed even when the concentration of NaCl was 0.1 kmol/m³. This SCC was also observed on the specimens with 0.2-0.5 kmol/m³ NaCl. Though SCC was observed in the corrosive solutions of 2.5 kmol/m³ H₂SO₄ when NaCl was 0.1-0.4 kmol/m³, no SCC was initiated when NaCl was 0.5 kmol/m³. For the case of 3.5 kmol/m³ H₂SO₄, SCC was observed when the NaCl concentrations are 0.1, 0.2 and 0.3 kmol/m³, while it was observed only when the NaCl was 0.1 kmol/m³ for the case of 4.5 kmol/m³ H₂SO₄. In addition, no SCC was recognized at any concentration of NaCl for the case of 5.5 kmol/m³ H₂SO₄, and only general corrosion was observed at every concentration of NaCl. According to these results, it is obvious that the concentrations of both H₂SO₄ and NaCl correlatively influence the corrosion behavior. The influence of potential on corrosion behavior is as follows. In the cathodic side from -0.353 V of natural electrode potential, SCC was observed, where the number of cracks increases with a decrease of potential. In anodic side from -0.353 V to -0.220 V, only SCC was observed. Between -0.220 V to -0.180 V general corrosion as well as SCC was recognized. At -0.150 V only general corrosion was observed and no SCC was initiated.