5th International Conference on Materials and Reliability
Jeju, Korea, Nov. 27-29, 2019

Effect of Corrosion Characteristics on Long-Term Aging of Austenitic 304 Steel

C. E. Huh[1], M. S. Kim[1], S. B. An[1] and C. S. Kim[1*]

[1] Department of Materials Science and Engineering, Chosun University, Gwangju 501-759, Republic of Korea

[*]Corresponding author: chs2865@chosun.ac.kr

1. Introduction

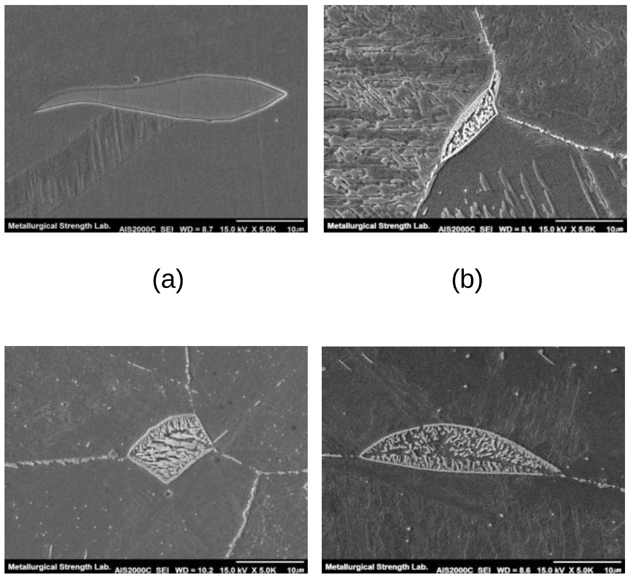
Austenitic stainless steels are chrome-nickel alloy steels with excellent corrosion resistance, high strength and good weldability. They are widely used as raw materials for plant piping and structural materials. Structural materials having excellent mechanical properties are become deteriorated due to high temperature, high pressure, and long-term use [1-3]. In particular, when the austenitic stainless steel is exposed at a temperature between 600℃ and 800℃, it is susceptible to sensitization. During sensitization, carbides are depleted in the boundary regions of the alloying elements and are formed along the grain boundary and twin boundary [4]. In this study, the effect of deformation due to the sensitization behavior of AISI 304 austenitic stainless steels was studied. In addition, the effect of corrosion characteristics on long-term aging treatment of austenitic stainless steels has been investigated.

2. Experimental Details

The test material used, in this study, was a austenitic stainless steel AISI 304. The samples were submitted to solution heat treatment at 1200 ℃ for 6 hours, followed by quenching in water. The quenched specimens were subjected to aging treatment in an electric furnace at 700 ° C for up to 10000 hours with time as a variable. In order to observe the microstructure of the test samples, they were cut through machining and polished using sand paper between 200 to 4000 mesh, followed by polish in Al_2O_3 solution with particle size of 0.5 ㎛. After preparation, the sample were chemically etched in a Vilella's reagent. The microstructure of test samples was investigated with an optical microscope (OM) and a scanning electron microscope (SEM). The current density (Icorr) and corrosion potential (Ecorr) were measured by the electrochemical polarization experiment.

3. Results and Discussion

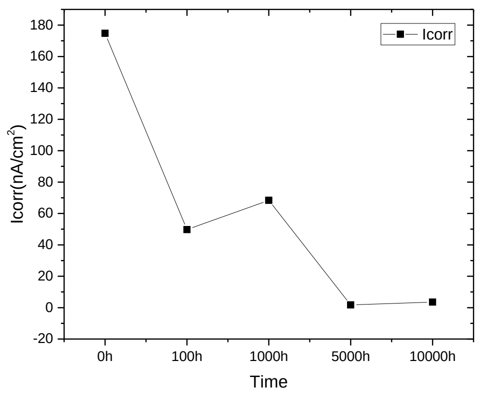
Fig. 1 shows photograph of δ-ferrite observed with a scanning electron microscope. As the aging time increases, δ-ferrite decomposition proceeds, and the precipitated δ-ferrite decomposes into σ phase and $M_{23}C_6$ with aging time [5].



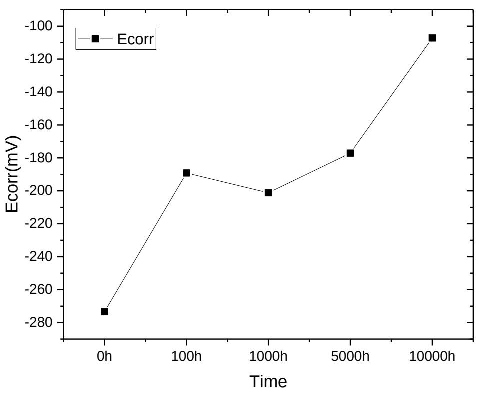
(a) (b) (c) (d)

Fig.1 SEM micrographs at each aging time showing (a)0h, (b)100h, (c)1000h and (d)10000h

Fig.2 shows the results of the electrochemical corrosion test using current density (Icorr) and corrosion potential (Ecorr) with 0.5wt% NaCl. As the aging time increased, the Icorr decreased and Ecorr increased. This variation in Icorr and Ecorr, as the aging time increases occurs due to the formation of the $M_{23}C_6$ carbide precipitates, which potentialize the corrosive attack on grain boundaries. Also, this typical precipitate along grain boundaries reduces the formation of the Cr_2O_3 passive layer and protection capacity against corrosion on the long-term aged samples.



(a)



(b)

Fig.2 Electrochemical polarization test showing the variation in current density and corrosion potential: (a) current density Icorr and (b) corrosion potential Ecorr.

4. Conclusion

The effect of corrosion characteristics on long-term aging of austenitic 304 steel has been investigated at the temperature of 700 ℃ up to 10000 hours. The following conclusions were drawn:

1. As the aging progresses for a long time, the size of the grains and precipitates of $M_{23}C_6$ on the grain boundaries become increases to minimize the surface energy.

2. The δ-ferrite is decomposed into σ phase and $M_{23}C_6$ carbide with aging time increase. This dissolution of δ-ferrite was mainly attributed to the excess Cr depletion in the δ-ferrite resulting from the Cr carbide precipitation.

3. As the aging time increased, Icorr decreased but Ecorr increased. This variation occurs due to the formation of $M_{23}C_6$ carbide along austenite grain boundaries with aging time increase.

Acknowledgment

This research was supported by the National Research Foundation of Korea (NRF) funded by the Ministry of Education (No. 2017R1D1A3B03028681).

References

[1] L. P. Stoter, Thermal Aging Effects in AISI type 316 Stainless Steel, MATER SCI+. 16, 1039-1051 (1981).
[2] S. Goyal and R. Sandhyam, The Effect of Therm Aging on Low Cycle Fatigue Behaviour of 316 Stainless Steel Welds, Int J fatigue, 31, 447-454 (2009).
[3] T.Jayakumar, High Temperature Materials for Nuclear Fast Fission and Fusion Reactor and Advanced fossil Power Plants, Procedia Engnieering 55, 259-270 (2013).
[4] L.V. Jin-long and L. Hong-yun, Mater. Chem. Phys. Vol. 135, 973 (2012)
[5] Tseng, C. C, Fracture and the foramation of sigma phase, M23C6, and austenite from delta-ferrite in an AISI 304L stainless steel, Metallurgical and Materials Transaction A 25.6, 1147-1158 (1994)