Comparison of corrosion resistance of stainless steels in sour environments with various chloride concentration and temperature

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Recently, deep water resource (oil) usage has been increased. The stainless steels used for drilling purpose are exposed to highly corrosive environment having high concentration of chloride ion and hydrogen sulfide (H_2S). Hence, highly corrosion-resistant stainless steels are needed in this environment. Typical corrosion types observed in sour environment containing chloride ion are localized corrosion and sulfide stress corrosion cracking (SSCC). Therefore, it is necessary to select the appropriate stainless steels in the components for deep water drilling to avoid these corrosions. In this study, we studied the corrosion behaviors of austenitic and duplex stainless steels in H_2S containing solutions by varying Cl^- concentration and temperature.

NACE 01-77 standard solution was used as a base solution for corrosion tests. Furthermore, different concentration of NaCl was added to the solution. Type 304L and 316L austenitic stainless steels and 22% Cr base Mo-saving and Ni-saving type duplex stainless steels were prepared for tests. To investigate corrosion behavior of the stainless steels, potentiodynamic tests were carried out in the neutral chloride solution and the solutions containing H_2S and Cl^- (1,000 ~ 100,000 ppm) at 25 ^oC and 90 ^oC. The SSCC tests were conducted using 4-point bent beam specimens by varying temperature from 25 to 150 ^oC and [Cl^-] from 1,000 to 100,000 ppm. Cracks around holes in the specimen were observed by optical microscopy. XPS was employed for quantitative analysis of the surface film after the experiment.

In neutral chloride solutions, the resistance to pitting corrosion of type 304 and 316L austenitic stainless steels and 22%Cr Mo-saving lean duplex stainless was measured to be proportional to PREN value. However, Ni-saving lean duplex stainless steels exhibited larger deviation from PREN line due to their high Mn concentration. When the modified $PREN_{Mn}$ value was employed instead of PREN, the better correlation was observed between the resistance to pitting corrosion and $PREN_{Mn}$. In H_2S containing solutions, Ni was found to largely affect the corrosion rate of stainless steel. This indicates that Ni-saving lean duplex stainless steel can exhibited poor resistance to general corrosion than conventional duplex stainless steel in sour environment. Furthermore, we suggested the $PREN_{Ni}$ to reflect the effect of Ni and Mn on the general corrosion rate of stainless steel in sour environment. Type 304L stainless steel was found to be susceptible to SSCC in all test environments. The resistance to SSCC of the lean duplex stainless steels were degraded around 80 ^oC. Surface film formed on the surface of stainless steels were composed of major amount of oxide and minor amount of sulfide compound.

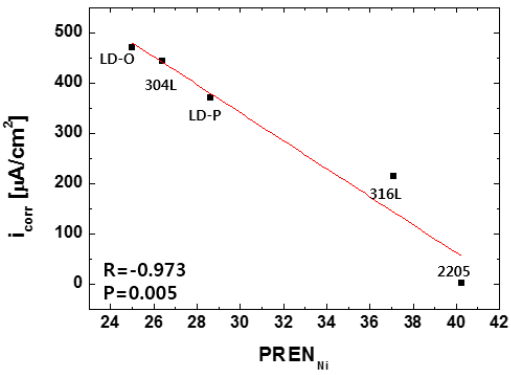

Fig. 1. Correlation between the corrosion rate and the suggested $PREN_{Ni}$ of stainless steels, measured from potentiodynamic tests in a sour solution containing 100,000 ppm [Cl^-] at 90 ^oC.