Application of PPR and CPT Tests to Study the Pitting Resistance of Stainless Steels

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ABSTRACT

The resistances to pitting of stainless steels were evaluated by measuring pit propagation rate(PPR) and critical pitting temperature(CPT) in aqueous 0.1N H_2SO_4 + 0.1N NaCl solution. The effect of alloying elements such as Cr, Mo, and N on the pitting resistance of stainless steels was investigated by the comparison between Polarization, CPT and PPR test results with regard to pitting resistance equivalent. The pitting resistance equivalent value may be identified as the good parameter representing the extents of the pitting resistance on a single scale irrespective of alloying elements and the types of ferritic or austenitic stainless steels

INTRODCUTION

Characterizing the pitting resistance of stainless steels has for many years been an attractive topic among corrosion scientists. Pitting resistance is one of the most important properties of stainless steels, roughly correlated with the resistance to the other localized corrosion such as crevice corrosion and stress-corrosion cracking. Electrochemical parameters such as the pitting potential obtained from the potential-current behavior have long been used with some limitations due to the differences in pitting resistance of stainless steels in terms of engineering view points. In order to characterize the pitting resistance by the other parameters than the pitting potential, the concepts of Pit Propagation Rate(PPR) and the Critical Pitting Temperature (CPT) were introduced by Syrett [1] and by Brigham and Tozer[2], respectively. The PPR is associated with the determination of the current density produced due to the pit propagation divided by the pit area while the CPT corresponds with the temperature indicating the critical pitting current density obtained by increasing temperature at the specific applied potential within the passive potential range. The effect of alloying elements such as Cr, Mo, and N on pitting resistance can be expressed in terms of a Pitting Resistance Equivalent(PRE). The concept of PRE was originally introduced by Lorentz and Medawar[3] who found good correlation between the pitting potential of a wide range of stainless steels and the sum of %Cr + 3.3 x (%Mo). The general expression was also reported as follows: PRE = %Cr + a x (%Mo) + b x (%N). Recently PRE equation was more developed by Jargelius-Pettersson[4] as follows: PRE = Cr + 3.3 x [%Mo] + 36 x [%N] + 7 x [%Mo][%N] – 1.6 x [%Mn], considering the synergistic effect of Mo and N. In the present work, the effects of Cr, Mo, and N alloying elements on the pitting resistance of both ferritic Fe-Cr, Fe-Cr-Mo alloys and austenitic stainless steels were investigated by the comparison between Polarization, PPR and CPT test results in terms of PRE values.

EXPERIMENTAL

Fe-x Cr (x=18, 25, 30, 40, and 100 wt%) and Fe-18%Cr-x Mo (x=0, 1, 4, and 6 wt%) alloys were prepared by melting in vacuum arc melting furnace back-filled with argon. Types 304, 304LN, 316L, and 316LN austenitic stainless steels with the variation of N concentrations from 0 to 0.15 wt%) were prepared in the form of ingots by melting in vacuum induction melting furnace. 0.1N H2SO4 + 0.1N NaCl acidic solution was prepared with distilled water. A saturated calomel electrode(SCE) was used as a reference electrode to measure the electrode potentials. PPR tests were performed by using a potentiostat controlled by a computer software following the Syrett'[1]s anodic potential cycle. CPT tests were carried out by using flushed-port cell, a potentiastat and a temperature controller with a computer software following ASTM G150 [5].

RESULTS

Fig. 1 shows the relationship between PRE and CPT of Fe-Cr, Fe-Cr-Mo ferritic alloys and austenitic stainless steels. Fig. 2 shows the relationship between PRE and PRE of ferritic and austenitic stainless steels. Results show that the increase in PRE leads to the decrease in pit propagation rate and the increase in the critical pitting temperature, indicating that PRE can be the good parameter to estimate the extents of their pitting resistance on a single scale, regardless of types of alloys and the content of alloying elements.

ACKNOWLEDGEMENTS

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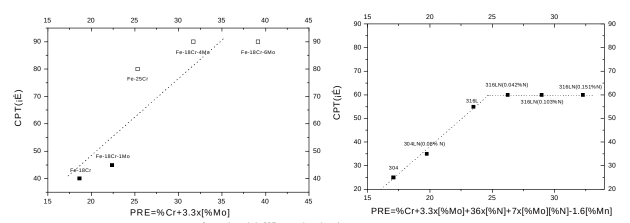
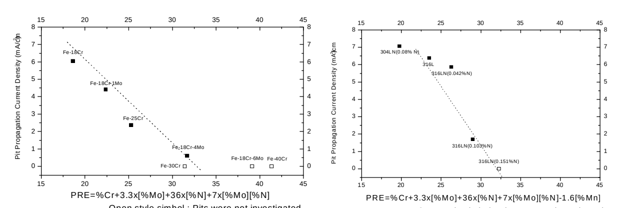
FIGURES



(a) (b)

Fig. 1 Relationship between PRE and CPT of alloys in the deaerated 0.1N H_2SO_4 + 0.1N NaCl solution: (a) ferritic alloys at –0.1 V_{sce}, (b) austenitic stainless steels at 0.4 V_{sce}



(a) (b)

Fig. 2 Relatioship between PRE and PPR of allys in the deaerated 0.1N H_2SO_4 + 0.1N NaCl solution: (a) ferritic alloys at –0.1 V_{sce}, (b) austenitic stainless steels at 0.4 V_{sce}