Effect of Oxygen Differential Aeration on Iron Corrosion Mechanism

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It is very challenging to study differential concentration corrosion (DCC) mechanism through an experimental method because of the constrained space and geometric complexity in a Z-shaped pipe. Therefore, in this study, numerical modelling was applied to investigate DCC in a Z-shaped pipe. The oxygen concentration distribution in the ionic conductive layer near the pipe wall is firstly calculated. Then, based on the ionic conductive layer, the natural corrosion potential and current density of the surface unit are calculated according to the oxygen concentration. Finally, according to Kirchhoff's Second Law, the discrete equations of the corrosion potential of the ionic conductive layer are derived. The solution of these equations are the corrosion potential of the unit after polarization and the corrosion current density distribution on the pipe surface. Calculated results show that in the elbow region of a Z-shaped pipe, without considering DCC in the calculation, the calculated natural corrosion potential and current density in the condition of high oxygen concentration become high, and vice versa. But, if DCC is considered, the anodic polarization occurs at the location with low natural corrosion potential, increasing the corrosion rate; the cathodic polarization occurs at the location with high natural corrosion potential, reducing the corrosion current. The polarization greatly changes the distribution of the corrosion current so that the corrosion potential tends to homogenize. This study helps clarify the corrosion mechanism of elbow in a Z-shaped pipe and explain the reason for an early damage of the extrados of pipe elbow rather than intrados region.

Keywords: Corrosion; Differential concentration corrosion; Polarization; Z-shaped pipe; Finite element method.

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