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(720) Effects of the Cathodic Charging Current Density on the Apparent Hydrogen Diffusivity through Pure Iron

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I. Introduction

In order to reduce the hydrogen embrittlement in steel, the effects of trap density and trap characteristics on the hydrogen apparent diffusivity have been extensively investigated. However, upto now, the effects of the cathodic charging current have not yet been studied. This work focuses entirely upon the effects of the cathodic charging density on the apparent diffusivity.

II. Experimental Method and Results

Ferrovac iron was used for the specimen, under two conditions: 40 % cold rolled; and fully annealed. All the permeation experiments were carried out using an electrochemical cell originally developed by Devanathan and Stachursky.[1] Palladium was plated onto both sides of membrane. Both cathodic and anodic solutions were a 0.1N NaOH solution and cathodic charging current density was varied from 10 $\mu A/cm^2$ to 2 340 $\mu A/cm^2$. The hydrogen permeation curves are shown in Fig.1. The breakthrough time of cold rolled specimen varies about 30 times as a result of adjusting the cathodic charging current density from 15 $\mu A/cm^2$ to 1 mA/cm^2. The hydrogen permeation curves of cold rolled specimen at low currents (charged under 25 $\mu A/cm^2$) exhibit a double plateau shape which differs considerably from the permeation curves obtained at high current density (above 40 $\mu A/cm^2$).

III. Discussion

A theoretical relationship between apparent hydrogen diffusivity and the cathodic charging current density is derived from the hydrogen trapping theory[1] and a simple electrochemical model,[1] the derived equation being $D_A = A \cdot i^{0.5}$, where D_A is the apparent hydrogen diffusivity, i is the cathodic charging current density and A is a constant. The apparent diffusivity calculated from breakthrough time is plotted against $i^{0.5}$ in Fig.2 which shows a linear relationship. This means that the apparent diffusivity is a function of the amount of lattice hydrogen solubility, and the origin of this concentration dependence is the hydrogen - trap interaction.

IV. Conclusion

The dependence of apparent hydrogen diffusivity on cathodic charging current density is measured and explained in terms of a trap theory and a simple electrochemical model.

REFERENCE

1) M.A.V.Devanathan and Z.O.J.Stachursky: Proc. Roy. Soc. A270, (1962), 90.

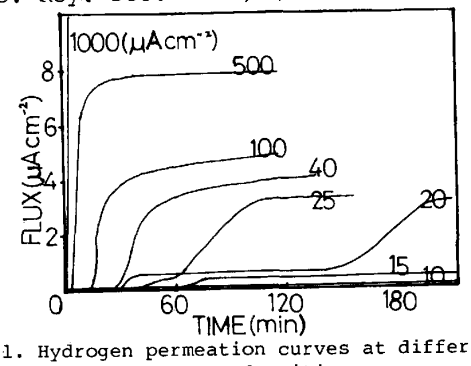

Fig.1. Hydrogen permeation curves at different charging current densities.

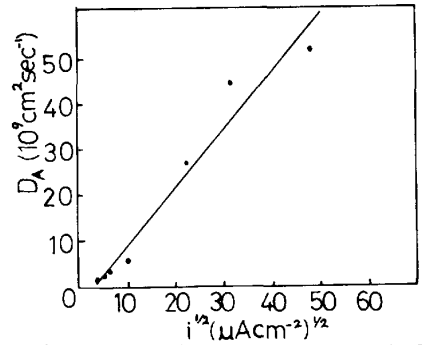

Fig.2. Linear dependence of apparent hydrogen diffusivity on the square root of charging current density.