Numerical Analysis on Hydrogen Diffusion Behaviour in Multi Materials Related to Weld Joint

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Authors have been founded that hydrogen diffusion and concentration behavior for notched specimens of multi-materials with space distribution of various material properties were dominated not only by the space gradient of hydrostatic stress caused by the notch tip, $\nabla \sigma_P$ but also by that of diffusion coefficient, $\nabla D(T, HV, \varepsilon_P)$ caused by space distributions of temperature, hardness and plastic strain due to multi-materials. In this research, on the basis of our proposed coupled analysis of heat transfer induced thermal stress driven hydrogen diffusion, the effect of $\nabla D(T, HV, \varepsilon_P)$ on hydrogen concentration behavior was clarified by solving the problem of hydrogen diffusion and concentration behavior in the y-grooved weld joint during cooling process which typically causes this effect as the differences of material properties among base metal (BM), heat affected zone (HAZ) and weld metal (WM). Where $T(x, y, t)$, HV (x, y, t) and $\varepsilon_P(x, y, t)$ is value of temperature, hardness and plastic strain at the time of cooling process, t and the site of x, y respectively. These analyses showed that the effect of $\nabla D(T)$ alone was found to be effective to release hydrogen from the maximum site of hydrostatic stress where hydrogen was mechanically locked. Furthermore, in the isotropic elastic material of which the effect of hardness and plastic strain are not typical, region of hydrogen concentration exists at the site of the center site of WM linked with the bottom of notch of the y-groove which closely connects with the site of maximum value of hydrostatic stress. However, for the case with the distribution of hardness among BM, HAZ and WM, region of hydrogen concentration shifts to the site of HAZ near the bottom of notch and it becomes much more typical with increase in plastic strain. These behaviors are in good agreement with experimental results of hydrogen embrittlement cracking. From these results mentioned above, behavior of hydrogen concentration was found to be dominated not only by the effect of $\nabla \sigma_P$ but also by $\nabla D(T, HV, \varepsilon_P)$ which is the factor of material science.