EFFECTS OF PRE-EXISTING HYDROGEN TO STRESS TRIAXIALITY AND DAMAGE EVOLUTION ON ULTRA HIGH STRENGTH STEEL

Hye-Jin Kim, Hyundai-Steel Company; Seoul National University, South Korea
Khj020911@hyundai-steel.com
Gun-Jin Shin, Seoul National University, South Korea
Heung-Jin Park, Seoul National University, South Korea
Myoung-Gyu Lee*, Seoul National University, South Korea
Ki-Jung Kim, Hyundai-Steel Company, South Korea
Seung-Chae Yoon, Hyundai-Steel Company, South Korea
Seung-Pill Jung, Hyundai-Steel Company, South Korea

Recently, for reinforcing the regulation of CO2 emission and growing environmental concern in the automobile industry, uses of ultra-high strength steels (UHSSs) above 1GPa grades are gradually increasing as the means of car-body weight reduction for automobiles. However, it is well-known that a little limitation presents due to concerned issue on hydrogen embrittlement (HE) for usage in case of the UHSSs. Research on the ignition and fracture characteristics of materials by hydrogen injection has been conducted by many researchers. However, there are limited research on securing the Hydrogen enhanced localized plasticity (HELP) or hydrogen enhanced de-cohesion (HEDE) experiment method by hydrogen influence and fracture or damage criterion using it and applying it to computer simulation at the finite element level. Most numerical studies of hydrogen transport utilize computational simulation at the atomic level, but have not reached the level that can be linked to larger scale computational simulation (e.g., crystal plasticity, continual-plastic analysis model). Therefore, the direction of experimental R&D in the future is to enable the development of a model corresponding to each scale, the securing of material model constants necessary for it, and the verification of the model.

In this study, we investigate feasibility on hydrogen diffusion and fracture model based on the experimental approach using finite element method (FEM) on the 1.5G tensile strength martensitic steel. The fracture trajectory analysis was performed to quantitatively assess the role of the pre-existing hydrogen with respect to the overall deformation modes. It is reasonable to assume that the effects of hydrogen with various level on ductile fractures would be more pronounced under triaxial stress conditions generated by introducing as a given specimens, as Notched tensile, Plane strain, Central hole, and Shear mode. The 4 type of specimens were tested under differential hydrogen concentration using slow strain rate tensile test (SSRT), in a similar manner, to quantitatively evaluate effect of triaxial stress conditions corresponding to fracture strain estimated using digital image correlation (DIC). In respect of simulation, the hydrogen diffusion prediction was based on Oriani model [1] and the combined ductile and brittle fracture models [2] were supposed in this study. As a results, the developed fracture model was validated on compact-tension specimen, and the feasibility was verified on hydrogen diffusion and fracture phenomenon based on numerical and experimental approach.

[1] R.A Oriani , “The diffusion and trapping of hydrogen in steel, Acta Metallurgica 18 (1) (1970): 147-157.
[2 Dadfarnia, M, Sofronis, P, and Neeraj, T. "Hydrogen Interaction with Multiple Traps: Can It Be Used to Mitigate Embrittlement?" International Journal of Hydrogen Energy 36 (16) (2011): 10141-0148.