SUMMARY OF Ph.D. DISSERTATION

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Title

Mechanistic aspects of hydrogen induced cracking in structural steels under hostile environments

Abstract

Although many studies have been made on the evaluation of delayed fracture mechanisms using notched specimens or those with artificial stress raisers with the focus on the hydrogen diffusion and concentration ahead of the artificial crack tip, some essential problems remain unsolved regarding the basic mechanisms on the initial crack development. These results using notched specimens of high strength steel revealed that the intergranular (IG) crack first initiated at the front of the notched root triggering fracture. On the other hand in the low strength steel, the transgranular (TG) crack first nucleated at the subsurface as the initial crack mode in low strength steel. It seems from these studies that the delayed fracture mechanisms may be different in high and low strength steels from the viewpoint of crack propagation morphology. Unnotched specimens instead of notched specimens were employed to have an essential understanding of the initial crack development using the SEM factrographic methods.

In this dissertation, mechanistic aspects of the mechanisms of subsurface crack propagation and the hydrogen degradation in high and low strength steels with various magnitudes of yield strength ranging from 500MPa to 1400MPa were studied with special emphasis on the influence of specimen shape and dimensions. A study has also been made on the mechanisms of critical crack development and the susceptibility to delayed fracture in the welded joints of API X80 steel as an example of the actual structure.

The present dissertation consists of five chapters. In chapter 1, the background and previous studies in this field are summarized, and the aims and framework of this dissertation are described.

In chapter 2, the influence of local stress conditions on hydrogen induced cracking is studied by employing extremely thin thickness specimen of high strength steels. The fracture lifetime in delayed fracture under hydrogen attack shows a tendency to increase with decreasing the thickness of specimens in quenched and tempered S35C and ASTM A490 steels. This can be explained by the evidence that the initial QC crack prefers to develop at the thicker section rather than the thinner section of the specimen, which has both thick and thin sections in a single specimen. Under the identical stress condition the thickness of the specimen is one of the important parameters making influence on the fracture lifetime under hydrogen attack.

In chapter 3, crack propagation mechanisms of high and low strength steels under sustained load with hydrogen are investigated with emphasis on the influence of the various levels of yield strength, which were obtained by changing the heat treatment condition. The susceptibility to delayed fracture in steels can be explained from the degree of crack tip blunting due to the level of yield strength of the specimens.

In chapter 4, hydrogen embrittlement behaviors of the weld metal and the base metal were studied with an emphasis on the susceptibility to delayed fracture and initial crack development and on the propagation mechanisms of fracture using the four types of unnotched specimens. Even though the weld metal has a high performance in mechanical properties compared to the base metal in air, the fracture occurred from the weld metal region not from the base metal region under hydrogen attack. It can be explained from the experimental evidences that the weld defects such as blowholes were the most susceptible site and provided an nucleation sites of QC cracks development in the crack propagation process under hydrogen attack.

In chapter 5, conclusions are summarized.