Electrochemical Behaviour of High Stress Steel (AISI 4340) in CO_2 Environments with the Presence of H_2 Gas

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Keywords: Stress corrosion cracking, polarization diagram, high stress steel.

Abstract. This research studied effects of CO_2 and H_2 gases on electrochemical behaviour of high stress steel (HSS) by using scan polarization graph to measure corrosion rate, corrosion potential and pitting potential. The tensile test samples with and without notches were tested under constant stress of 20% and immersed in 3% NaCl solutions. During experiments, CO_2 gas was injected into the samples. To generate H_2 gas, the samples were employed cathodically over potential at - 1700 mV (Ag/AgCl) for three days. The results indicated that both CO_2 and H_2 gases have increased the corrosion rate. Potentiodynamic graph showed that there were changes in pitting potential where the effect of CO_2 gas would decrease the pitting potential. However, the presence of the notch did not show any significant difference in corrosion rate.

Introduction

The selection of steels for oil and gas environments containing CO_2 and H_2 gases require appropriate testing to ensure resistance to cracking in the field conditions [1, 2]. The employ of CO_2 and H_2 gases in the environments of oil and gas production are one of the important stages in considerations to design the pipelines. Other factors such as total tensile stress, residual stresses, process temperature and exposure time should also be accounted. Hydrogen stress cracking can occur under applied stressed or strained conditions. It propagates perpendicularly to the tensile stress direction [3].

Hydrogen gas can be produced by the dissolution of atomic hydrogen in the steel as a result of reduction of water molecules by cathodic overprotection. This condition is another potential source of reduced H^+ ions [4]. Those gases are widely exist in the oil fields and could increase corrosiveness of the environments. Its existence serves as indication as source of early failures of the pipeline. Degree of corrosiveness of H_2 gas is influenced by environmental conditions such as temperature, CO_2 partial pressure, corrosion film properties and mechanical properties of the materials [5].

Experimental Setup

The specimens tested were HSS steel (AISI 4340) with chemical composition as shown in Table 1. The geometry of the specimens were as follows: gauge length: 25 mm, and diameter: 6 mm. Before immersing, the specimens surfaces were polished successively with 240, 400 and 600 grit SiC paper, rinsed with methanol and degreased using acetone. The test matrix which was used in the experiment is presented in Table 2. Samples were applied pre-strained under tension stress of 20% as presented in Fig.1.