Development of A Mechanistic Model for Predicting Flow-Induced Bottom Line Corrosion (BLC)

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Abstract

Presently, one of the insurmountable topics in corrosion research is to gain an insight into in-situ denigration mechanism on a scale concealed corroding surface. To access this knowledge, a Helmholtz concept of flow-induced bottom line corrosion (BLC) in mild steel pipeline, was studied by installing a Bio-Logic ASA Potentiostat Electrochemical analyzer to a horizontal duct. With metal mine effluents (MME) and synthetic seawater (SSW) solution, respectively, streaming over the test specimen for 24-and 192-hours. Thus, this mechanistic approach takes into account the electrochemical kinetics, hydrodynamic pressure and velocity, charge-mass transfer parameters and pit perforation. The concurrence between the model results (i.e. hydrodynamic parameters and velocity potential) and the experimental data (i.e. potentiodynamic polarization (PDP) and electrochemical impedance spectroscopy (EIS)) are satisfactory. The internal corrosion rate behaviour which is inclusive to scale abrasions and impingement were explained by an (a) factor, constant phase element, polarization resistance, corrosion potential and corrosion current density

Keywords: *constant phase element; flow-induced bottom line corrosion (BLC); polarization resistance; pseudo-passivation; SSW/MME solution*

Introduction

Internal corrosion in pipelines is an omnipresent industrial challenge which bridges material science and engineering limits. Hence, extensive research efforts are dedicated to elucidating the complicated influence of environmental factors on corrosion. With studies showing that pseudo-passivation of mild steel under the amalgamation of siderite ($FeCO_3$), lepidocrocite (FeO(OH)), aragonite ($CaCO_3$), hematite (Fe_2O_3), mackinawite (FeS), and pyrite (FeS_2), noticeably increases the surface potential. Thus, creating a micro-galvanic cell which propagates internal localized corrosion such as BLC phenomena. In this study, $FeCO_3$, FeO(OH), $CaCO_3$, Fe_2O_3, FeS, and FeS_2 layer-covered surfaces are considered to undergo a substantial surface pH increase due to the charge transfer limiting effect, which triggers the pseudo-passive film formation and results in a potential increase of metal surface. Therefore, excessive charge-transport interaction triggers the overall cathodic charge density to be generated from the mass-transport rate. In environmental scenarios where a small portion of this film-covered surface loses the protective film, an active surface that has a lower potential will be exposed. A micro-galvanic cell can then be established between film-covered and active surfaces, which drives the active surface to corrode at a

higher rate. Based on these experimental findings, a parametric study is developed to simulate the Helmholtz model for flow-induced bottom line corrosion (BLC) process inside a mild steel pipeline. The model deciphers and elucidates key influencing factor, together with the corrosion rate-determining step which governs both uniform and localized internal corrosion, including hydrodynamic pressure and velocity, charge-mass transfer, chemical reactions, electrochemical reactions, iron carbide and iron sulphide layer formation (depending on the electrolyte-MME/SSW) and pit propagation. The model generates critical parameters involved in the corrosion process, such as the equivalent electrode circuit (EEC) solution resistance (R_1), charge transfer resistance (R_3), constant phase element (Q_3), charge transfer (a_1), product charge transfer (a_3), and, potentiodynamic polarization corrosion potential (E_{corr}), corrosion current density (I_{corr}), anodic Tafel slope (β_a) value, cathodic Tafel slope (β_c) value, corrosion rate (CR), of mild steel during MME/SSW flow. The generated data will equip researcher and engineers worldwide to better understanding the mild steel corrosion behaviour in pipelines.