World Academy of Science, Engineering and Technology
International Journal of Materials and Metallurgical Engineering
Vol:18, No:05, 2024

Application of Electrochemical Impedance Spectroscopy to Monitor the Steel/Soil Interface During Cathodic Protection of Steel in Simulated Soil Solution

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Abstract : Cathodic protection (CP) has been widely considered a suitable technique for mitigating corrosion of buried metal structures. Plenty of efforts have been made in developing techniques, in particular non-destructive techniques, for monitoring and quantifying the effectiveness of CP to ensure the sustainability and performance of buried steel structures. The aim of this study was to investigate the evolution of the electrochemical processes at the steel/soil interface during the application of CP on steel in simulated soil. Carbon steel was subjected to electrochemical tests with NS4 solution used as simulated soil conditions for 4 days before applying CP for a further 11 days. A previously modified non-destructive voltammetry technique was applied before and after the application of CP to measure the corrosion rate. Electrochemical impedance spectroscopy (EIS), in combination with mathematical modeling through equivalent electric circuits, was applied to determine the electrochemical behavior at the steel/soil interface. The measured corrosion rate was found to have decreased from 410 µm/yr to 8 µm/yr between days 5 and 14 because of the applied CP. Equivalent electrical circuits were successfully constructed and used to adequately model the EIS results. The modeling of the obtained EIS results revealed the formation of corrosion products via a mixed activation-diffusion mechanism during the first 4 days, while the activation mechanism prevailed in the presence of CP, resulting in a protective film. The x-ray diffraction analysis confirmed the presence of corrosion products and the predominant protective film corresponding to the calcareous deposit.

Keywords : carbon steel, cathodic protection, NS4 solution, voltammetry, EIS
Conference Title : ICCMELMS 2024 : International Conference on Chemical Metallurgy, Electrochemistry and Liquid Metal Solutions
Conference Location : Singapore, Singapore
Conference Dates : May 02-03, 2024