Accepted Manuscript

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PII: S0263-2241(16)30469-9
DOI: http://dx.doi.org/10.1016/j.measurement.2016.08.008
Reference: MEASUR 4286

To appear in: *Measurement*

Received Date: 25 October 2014
Revised Date: 2 August 2016
Accepted Date: 11 August 2016

NOVEL ELECTROCHEMICAL IMPEDANCE SIMULATION DESIGN VIA STOCHASTIC ALGORITHMS FOR FITTING EQUIVALENT CIRCUITS

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Abstract. Electrochemical impedance spectroscopy (EIS) is of great value to corrosion studies because it is sensitive to transient changes that occur in the metal-electrolyte interface. A useful way to link the results of electrochemical impedance spectroscopy to corrosion phenomena is by simulating equivalent circuits. Equivalent circuit models are very attractive because of their relative simplicity, enabling the monitoring of electrochemical systems that have a complex physical mechanism. In this paper, the stochastic algorithm Differential Evolution is proposed to fit an equivalent circuit to the EIS results for a wide potential range. EIS is often limited to the corrosion potential despite being widely used. This greatly hinders the analysis regarding the effect of the applied potential, which strongly affects the interface, as shown, for example, in polarization curves. Moreover, the data from both the EIS and the DC values were used in the proposed scheme, allowing the best fit of the model parameters. The approach was compared to the standard Simplex square residual minimization of EIS data. In order to manage the large amount of generated data, the EIS-Mapper software package, which also plots the 2D/3D diagrams with potential, was used to fit the equivalent circuit of multiple diagrams. Furthermore, EIS-Mapper also computed all simulations. The results of 67 impedance diagrams of stainless steel in a 3.5 % NaCl medium at 25 °C obtained in steps of 10 mV, and the respective values of the fitted parameters of the equivalent circuit are reported. The present approach conveys new insight to the use of electrochemical impedance and bridges the gap between polarization curves and equivalent electrical circuits.

Keywords: electrochemical impedance, impedance measurements, corrosion, differential evolution, optimization, stochastic methods

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1. INTRODUCTION

Electrochemical impedance spectroscopy is a linear technique applied to the study of corrosion and electrochemical systems [1]. The superposition of potential or current sine-wave at the points of the polarization curve produces the electrochemical impedance diagrams of the surface-electrolyte interaction. This characterization is of great importance as it allows the kinetic analysis of electrochemical processes. Polarization curves show the response of a steady-state interface, and are therefore used in most investigations on corrosion. Electrochemical phenomena are strongly dependent on potential. However, in most corrosion