Iterative Electric Potential Adjustment of Damaged Naval Vessels Using the Onboard ICCP-System

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Abstract

Naval vessels involuntary communicate with their surrounding environment via different signatures, which can be separated in acoustic, electric, magnetic, seismic and pressure signatures. The electric signature, also known as Underwater Electric Potential (UEP)-Signature is mainly caused by a corrosion process due to the vessel's different metallic materials when located in seawater. These distinct metals possess individual electric equilibrium potentials that when placed in seawater (electrolyte) behave like an acomnode (lower equilibrium potential) and cathode (higher equilibrium potential), respectively. This mechanism is similar to a galvanic cell and therefore a current flow from the anode to the cathode is involved leading to corrosion of the anodic electrode. Regarding naval vessels the hull mostly possesses a lower equilibrium potential, thus becoming the anode with a corresponding current flow from hull to the propellers. To prevent the corrosion process of the hull passive corrosion protection systems (coatings) and active protection systems can be used to force the hull in a cathodic regime. The active system considered in this work is the Impressed Current Cathodic Protection (ICCP)-System in which cathodic currents are actively impressed in a highly corrosion resistant anode to ensure a current flow from the ICCP-System to the hull and propellers, respectively. When the hull reaches a specific electric potential, it can be considered as protected against corrosion. However, preventing the corrosion process of the hull comes at the expense of a UEP-Signature. The impressed currents, namely, the occurring current density in the seawater, yield an additional contribution to the UEP-Signature that is superimposed to the underlying initial corrosion UEP-Signature. Hence, damages of the coating change the hull potential in a non-protective region and higher impressed currents are thus needed to re-establish the protection potential that is necessary to prevent further corrosion damages. In this work we present an iterative simulation process to restore the aforementioned protection potential after random damages to the hull are present. Here we use the COMSOL Multiphysics® simulation platform together with the LiveLink™ for MATLAB® and create a MATLAB® - based script for placing randomized damages and track the hull potential at specific reference points as well as at the damage points and use these information in a simple mathematic formulation to estimate and impress new protection currents to the ICCP-System in an iterative manner. For the corrosion process we use realistic non-linear polarisation-curve data and COMSOL's AC/DC module, more specifically the Electric Currents physics with the Stationary Solver to ensure very accurate and efficient

simulation setups. Using the COMSOL tutorial ship model we present a working setup to investigate the behavior of the ICCP-System when new hull damages occur. Finally, this iterative procedure could also be adapted for a real-time control scheme in e.g. ship models and in existing ICCP-System configurations.

Figures used in the abstract

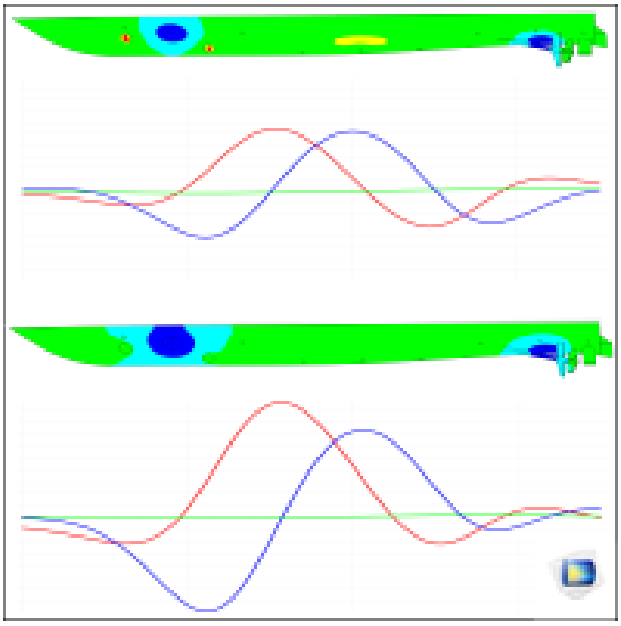

Figure 1: Naval vessel's protection potential and UEP-Signature simulation with two random damages (top figure) and newly adjusted ICCP-System (bottom figure).