

Transient Modelling of Corrosion Protection Systems with a Coupled BEM-Electrical Circuit Approach

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In order to prevent a ship from being corroded, active anodes are commonly used: by sending currents in seawater, they place hull-damaged areas in their electrochemical inactive domain. This corrosion protection system is called ICCP (Impressed Current Cathodic Protection). Nevertheless, the currents flowing in seawater induce a measurable electrical field around the ship that may be detected by submarine mine sensors, which is a main threat (Fig. 1, left).

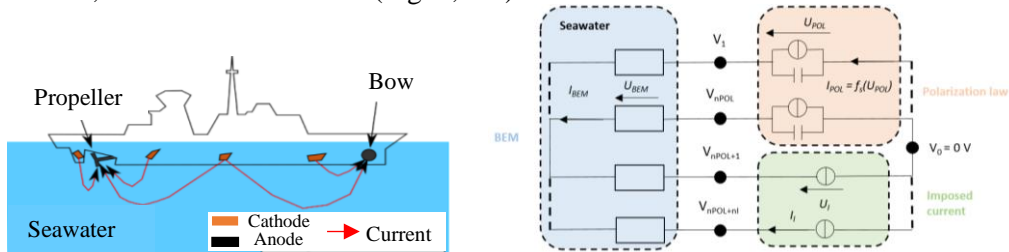


Fig. 1: Corrosion phenomena on ship hull (left) and its equivalent circuit (right). n_{BEM} resistances ruled by BEM equations model the electrolyte while the materials are considered as n_{POL} dipole composed of a polarization law and a capacitance. The ICCP is represented by n_I controlled current generators.

The modelling of this type of electromagnetic problem is well known in statics. As the seawater conductivity is assumed homogeneous, the Laplace equation inside the media is solved by using Boundary Element Method, with various conditions at the water/hull interface (N. G. Zamani, et al., “BEM simulation of cathodic protection systems employed in infinite electrolytes”, Int. J. for Numer. Methods Eng., vol. 24, pp. 605-620, 1987). Nevertheless, when the ICCP is enabled, dynamic effects occur on the signature. To model them, a transient approach is required. The present work proposes a BEM – electrical circuit hybridization that connects the electrical components representing the transient phenomena at the interfaces, to the ICCP external circuit. Figure 1 (right) presents the topology of the equivalent circuit. Each physical region of the discretized hull is associated to a given electrical circuit component: imposed current generators for the ICCP regions or impedance condition for the hull regions with nonlinear polarization laws including capacitances. The circuit is completed by a network of resistances ruled by a set of BEM equations, to represent the seawater.

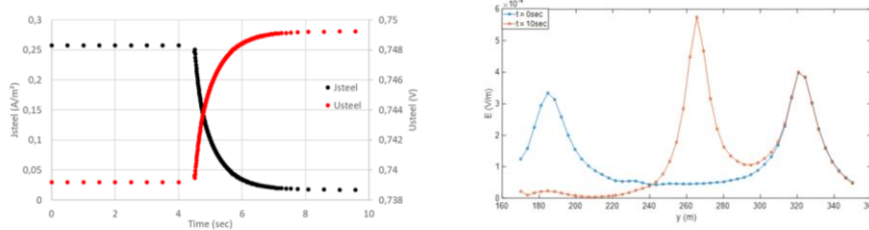


Fig. 2: Time dependency of the current/potential couple (left) and electric field (right) of a meshed ship hull steel.

A nonlinear transient solver has been developed to solve the state equation enabling the computation of electric quantities on the mesh and the associated electrical signature in seawater (Fig. 2). The full paper will present an experimental validation of the method and numerical electrical signatures computed for a complex ship mesh.