



# PhD in INGEGNERIA DEI MATERIALI / MATERIALS ENGINEERING - 40th cycle

**THEMATIC Research Field: DEVELOPMENT OF A MECHANISTIC MODEL FOR THE  
PREDICTION OF CORROSION RATE OF METALS IN ACIDIC CONDITIONS: THEORY AND  
APPLICATION TO SWEET CORROSION OF CARBON STEEL**

<b>Monthly net income of PhDscholarship (max 36 months)</b>
<b>€ 1400.0</b>
In case of a change of the welfare rates during the three-year period, the amount could be modified.

<b>Context of the research activity</b>	
<p><b>Motivation and objectives of the research in this field</b></p>	<p>Corrosion is a threat in several industrial applications and requires an active prevention and management strategy in which a reliable estimation of corrosion rate is key. Industrial environments are severely affected by acidic corrosion: the oil&amp;gas industry, for example, has an extensive problem of corrosion by carbonic acid (i.e., sweet corrosion) of carbon steel structures and infrastructures, as pipeline for the transport of production fluids.</p> <p>Sweet corrosion of carbon steel takes place when the metal is in contact with an environment rich in carbon dioxide, in presence of water. Despite being a threatening problem from the economic, environment and safety point of view, nowadays the corrosion mechanism is still not fully understood and different predictive models have been proposed. Most of them are of empirical or semiempirical nature, which limits their applicability outside the range of experimental conditions used to formulate them.</p> <p>The scope of the candidate's PhD research is to develop and validate a mechanistic model, called Tafel-Piontelli model, for the prediction of the corrosion rate of metals in acidic conditions, with application to sweet corrosion of carbon steel.</p> <p>The Tafel-Piontelli model, proposed and improved in the last five years starting from its base definition, is a mechanistic model for the calculation of the uniform</p>



	<p>corrosion rate of active metals (as carbon steel) exposed to acidic corrosion conditions, including the case of sweet corrosion. This model has deep theoretical roots since it is strongly based on the theory of kinetics of electrochemical corrosion, and is therefore a flexible and transversal model, able to account for new data.</p> <p>Despite the encouraging results and improvements obtained in the last years on the electrochemical definition of the model, new improvements are required in order to validate it in a wide range of experimental conditions of temperature, acidity and fluid dynamic condition. The model will be then applied to the case of sweet corrosion of carbon steel, with a critical comparison with existing models adopted in the industry.</p>
<p><b>Methods and techniques that will be developed and used to carry out the research</b></p>	<p>The research activity will be conducted through the following main phases:</p> <ol style="list-style-type: none"> <li>1) A comprehensive review on CO<sub>2</sub> corrosion of carbon steel, aimed at defining the electrochemical mechanisms, the influencing factors and the models proposed in the literature on the assessment of corrosion rate</li> <li>2) Theoretical development and improvement of the model, based on the thermodynamic and kinetic theory of wet corrosion</li> <li>3) Experimental validation of the new features of the model through long-term test for mass loss evaluation and electrochemical tests, namely potentiodynamic tests, and electrochemical impedance spectroscopy for the determination of kinetic parameters. Tests will be carried out in different environmental condition (type of acid – strong or weak, temperature, pH, stagnant or flow condition). Conventional techniques, such as SEM-EDS, XRD, will help the understanding of the corrosion morphology</li> <li>4) Once validated the accuracy of the model in the prediction of the corrosion rate in acidic solutions, a comparative analysis will be conducted with industry-consolidated corrosion models of sweet corrosion of carbon steel. Empirical, semi-empirical and mechanistic models will be considered in the analysis. Different scenarios of operating conditions will be considered in the benchmark activity</li> </ol>



	5) Final definition of the model and design of an informatic tool, as a MATLAB or Excel code, for the calculation of sweet corrosion rate by inserting input operating parameters.
<b>Educational objectives</b>	The candidate will develop a deep theoretical and experimental experience in the study of wet corrosion of metals and its assessment, and a specific knowledge on sweet corrosion mechanism of carbon steel. Robust competencies in the field of electrochemical methods and testing will be obtained.
<b>Job opportunities</b>	The experience accumulated in the 3 years will grant access to R&D departments in the field of corrosion and electrochemistry, as well as in companies and industries which deals with the protection of metals exposed to both natural and industrial environments, as o&g industry.
<b>Composition of the research group</b>	2 Full Professors 3 Associated Professors 3 Assistant Professors 3 PhD Students
<b>Name of the research directors</b>	Prof. Andrea Brenna

#### Contacts

Telephone: +39 02 2399 3119  
 Email: andrea.brenna@polimi.it  
 Web-pages of the research group: polilapp.chem.polimi.it

#### Additional support - Financial aid per PhD student per year (gross amount)

<b>Housing - Foreign Students</b>	--
<b>Housing - Out-of-town residents (more than 80Km out of Milano)</b>	--

#### Scholarship Increase for a period abroad

<b>Amount monthly</b>	700.0 €
<b>By number of months</b>	6

**Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information**

**Individual budget for research (tot. about 5.700 euro):**  
 1st year: 1.900 euro;



2nd year: 1.900 euro;

3rd year: 1.900 euro

**Teaching assistantship:** availability of funding in recognition of supporting teaching activities by the PhD student. There are various forms of financial of for activities of support to the teaching practice. The PhD student is encouraged to take part in these activities within the limits allowed by the regulation.